Materials & Methods

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New Creep Resistant Ferritic Steels

Joining Aluminum to Other Materials

What's New in Synthetic Rubber Modifications

High Temperature Silicone-Aluminum Paints

New Vinyl-Metal Sheet

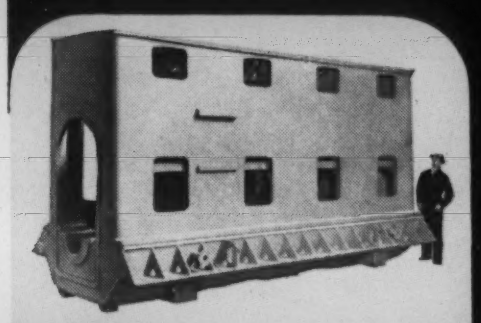
Cold Extruded Steel Shapes

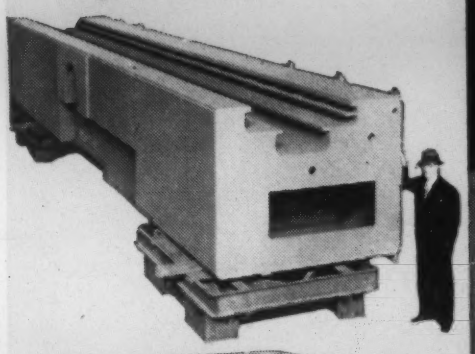
Vacuum Impregnated Steel Castings

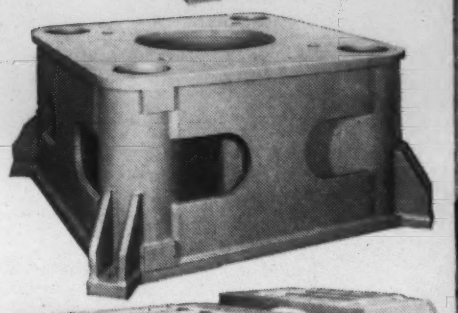
Selecting Materials in Mechanical Design

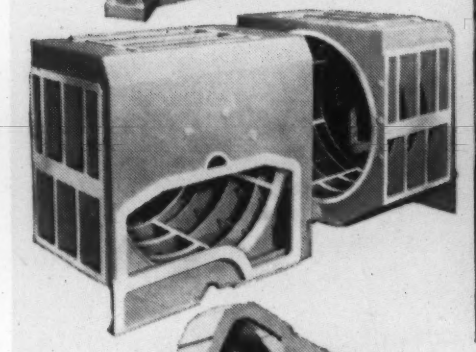
WOOD AND WOOD-BASE MATERIALS
—Materials & Methods Manual No. 97

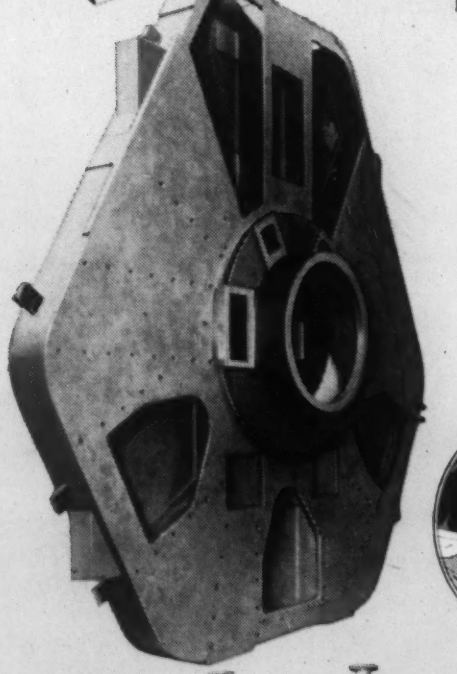
THE MAGAZINE OF
MATERIALS ENGINEERING
DEVOTED TO THE MATERIALS PROBLEMS OF PRODUCT DESIGN AND MANUFACTURE

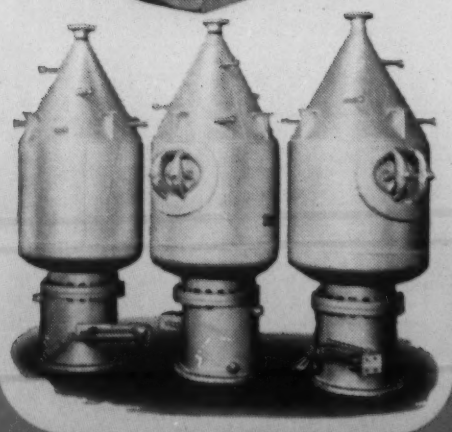




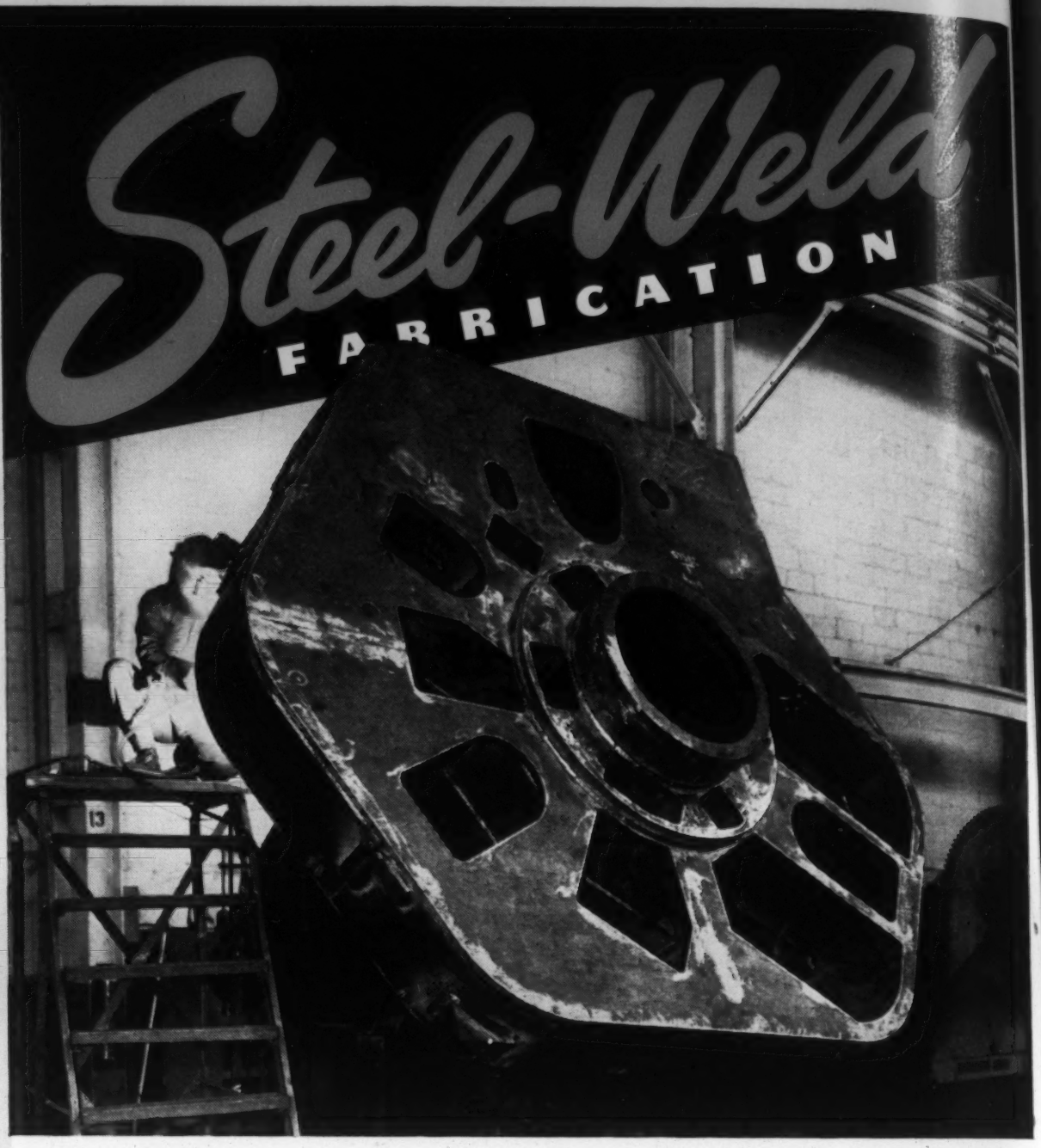








Steel-Weld FABRICATION



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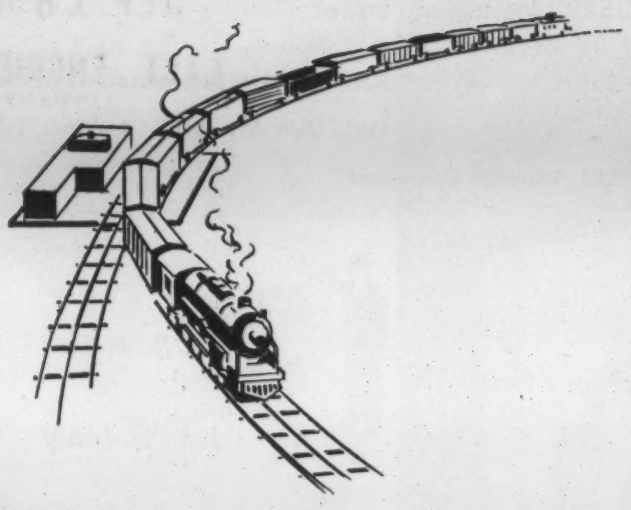

Lionel is on the right track

Here is an Inconel pusher tray designed by ALLOY ENGINEERING COMPANY, Berea, Ohio. The Inconel basket being loaded on the tray (above) contains parts that will be sintered at 2050° F. Each tray is "double-stacked" to utilize furnace capacity.

Pusher trays, like those used at The Lionel Corporation in Irvington, New Jersey, take a two-way beating.

Here's what a daily grind those tough, oxidation and corrosion-resisting Inconel® trays go through.

First, they are loaded with two Inconel baskets holding twenty pounds of parts each. Then they start on the journey through the 1650 to 2050° F. furnace, pushing the tray behind. The furnace atmosphere is exothermic or endothermic reducing gas. They spend 35 to 40 minutes in both the pre-heat zone and the hot zone and then two hours in the cooling zone.

And they go through this cycle as many as five times a day for as long as 15 months without failure. All they require is an occasional maintenance of welds and straightening. These trays are designed and fabricated by Alloy Engineering Co., Berea, Ohio.

It is advisable to place equipment orders with your supplier well in advance of scheduled use. Distributors of Inco Nickel Alloys can supply the latest information on availability from warehouse and mill.

Write to Inco for your copy of an interesting booklet for the heat treating industry. Ask for "Keep Operating Costs Down . . . When Temperatures Go Up."

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Inco Nickel Alloys

Inconel . . . *for long life at high temperatures*

The Materials Outlook

A permanent magnet material made by powder metallurgy from a mixture of barium and iron oxides is now being produced in this country. Initially developed by the Dutch it is said to have extremely high coercive force and unusually high resistance to demagnetization, as well as excellent magnetic stability. The ceramic contains no nickel, cobalt, tungsten, chromium or other critical materials. Lack of such elements may speed its acceptance in many fields for which government allocations of critical materials are restricted.

A heavy cellophane, claimed to be the strongest ever made, has been developed for packaging. Added durability was obtained by toughening the base film and by adding a coating which allows a stronger heat seal. Impetus for improvement was the growing trend toward prepackaging of textile goods for retail sale.

Lack of an assured market for large aluminum forgings and extrusions outside of the somewhat limited aircraft industry is causing cold feet to develop in the Air Force heavy press program. The government now wants the operating companies to provide the buildings to house the presses, and some companies, with a wary eye on recent Air Force budget cuts, aren't sure they want to invest that much with no assurance of continuing demand. The government, on the other hand, seems to think the new policy might persuade press operators to aggressively seek broad commercial outlets for large aluminum forgings and extrusions. If they were successful, the machines could be maintained in good operating condition and a skilled labor pool developed — both important assets in case of future need for mass aircraft production.

Titanium strip up to 8 in. in width and down to 0.005 in. in thickness, with tolerances held to ±0.0001 in., is now commercially available.

Possibility of somewhat lower prices for polyester laminates was raised by recent reductions in the price of maleic anhydride and fumaric acid by two chemical companies. . . . Although cost is an important drawback, epoxy resin-glass fiber laminates are getting increased attention in the reinforced plastics industry. The epoxies are particularly favored because of the high inherent adhesion between the resin and the glass, a property which appears to be especially important where the laminate is subjected to cyclic loads.

High-pressure moldings of epoxies, on the other hand, are still not practical for many applications. Chief difficulty is the molding cycle which is too long for high production. Difficulties with surface finish have also

(Continued on page 4)

The Materials Outlook *(continued)*

been experienced as a result of parting agents needed to counteract the strong tendency of the plastic to stick to the metal mold. Important uses in chemical process equipment and in low frequency electrical applications are anticipated for epoxy moldings if these difficulties can be overcome. Partial success has been achieved by blending the epoxies with other resins, such as phenolics.

The possibility of future improvement in silicon transformer steels seems to rest on the results of current studies on the control of grain growth. Today's steels can be produced with about 95% of the cubes standing on one edge and pointing in the same direction. Experts say that better control of grain growth may enable them to roll these cubes over flat so there would be two edge directions within the plane of the material and hence two magnetic directions at right angles to each other. This, they say, would reduce core losses and thereby save material and cut costs.

Rigid sheet of butadiene-modified polystyrene is now available in a greater range of dimensions than heretofore. Fabrication of this type of material by vacuum forming was described in the May issue of M&M, p 94. The new product is turned out in a continuous strip of widths ranging from 26 to 58 in. and thicknesses from 0.005 to 0.125 in.

A major zinc producer has discontinued the basing point system for pricing prime western grade zinc. Instead of a price of 11¢ per lb at St. Louis, the current price will be 11⅛¢ delivered at all points East of the Continental Divide and 11½¢ in the West. This amounts to a price reduction for all consumers except those in the Middle West who may pay more than before. . . . The company also increased the price of regular high grade to 12.60¢ in the East and 12.85¢ in the West; and special high grade zinc (used for die castings) to 12.75¢ in the East and 13¢ in the West.

Some other recent price changes on materials: A major aluminum producer hiked price of commercial aluminum ingot 1¢ per lb to a level of 21½¢ and standard aluminum pig ½¢ to 20¢. Other grades of ingot were increased from ½ to 1¢ per lb. Similar price increases on sheet, bar, rods and other shapes are expected shortly. . . . Price of tin continued to drop, falling below 80¢ per lb. . . . A big producer raised the price of cellophane about 2¢ to 57¢ per lb.

An improved rayon tire yarn has been developed. Its breaking strength of 3.35 g per denier represents a 20% increase over existing high-tenacity yarns and its cost is about 6¢ per lb more (67¢ per lb for 1650-denier size). It is expected to be competitive with nylon which has a breaking strength of 6.7 and sells at $1.65 per lb. Production will start this month.

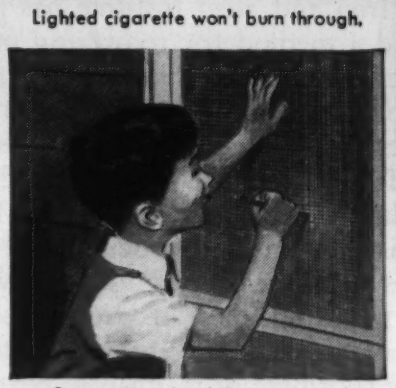
A new alkali-resistant glass is being used for glass-coated steel in chemical process equipment. Its acid resistance is reported to be similar to that of standard acid-resistant glasses, but at alkalinities up to pH 12 and temperatures up to 212 F it is said to show from two to four times the resistance of normal acid resistant glass.

Another new development using

B. F. Goodrich Chemical *raw materials*

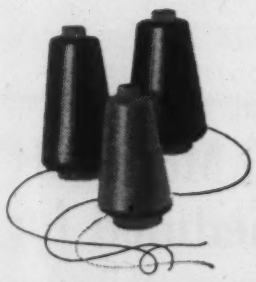
B. F. Goodrich Chemical Company does not make this yarn. We supply the Geon resin for the coating only.

Lighted cigarette won't burn through.



Outstanding durability—
won't stretch or corrode

Tough Screen made of Armored Glass Threads



Start with fibrous glass yarn, add a manufacturer who knows what Geon vinyl materials can do, and you come up with a new super-tough yarn that's headed for sales stardom—in a new type window screen, for instance!

Glass threads are treated with a formulation of Geon resin. The result: yarn with high tensile strength and abrasion resistance. It is fire and chemical resistant. It can be heat-sealed to vinyl film for extra reinforcement. Name your color—and you can get it.

Window screens woven of this yarn are but one outstanding example, with other uses in the offing.

Geon has a way of sparking good sales ideas. For Geon materials come in a variety of forms to fit so many needs—resin, plastic granules, liquid latex. They can be used for extrusions, molding, casting, coating or dipping. They can make products resistant to heat and cold, wear, oils, greases and many chemicals. Perhaps a Geon material can help you develop or improve products—we'll help with technical advice. Just write Dept. GN-5, B. F. Goodrich Chemical Company, Rose Building, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

GEON RESINS • GOOD-RITE PLASTICIZERS . . . the ideal team to make products easier, better and more saleable

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON colors

Manganese Sources:

Soot and Slag

May Ease Import Requirements

The steel industry is preparing to tap sources of manganese in its own back yard.

Recent developmental research by the Bureau of Mines and the American Iron and Steel Institute has provided a method for recovering manganese from slag which in time may supply half the metallurgical manganese required by the steel industry.

Most of the manganese used in steelmaking operations does not end up in the finished product, but absorbs impurities and is discarded with the slag. The new recovery process consists of a relatively simple two-stage treatment of manganese-bearing slag in blast furnaces and basic converters. There is no particular technical difficulty other than the omnipresent one of reducing costs to compete with imported manganese prices. As a potential domestic source, recovery of manganese from slag is already much more economical than any process yet found to extract the metal from mean, lean, domestic ores.

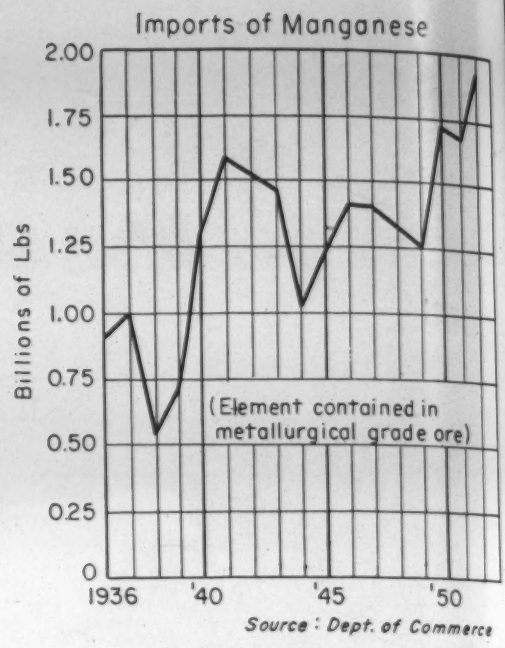
A major steel producer recently reported another potential source of manganese in the waste collected by precipitators installed in the stacks of ferromanganese furnaces. The "soot" from a single plant collects at the rate of 10 tons per hour and contains as much as 14% manganese. While the waste is rich, it is also mean due to the extreme fineness of the particles, and recovery operations will require special equipment. Waste volume does not yet warrant construction of special recovery facilities, but the stack waste is being compressed and stored until more furnaces are equipped with precipitators, or manganese becomes critically short.

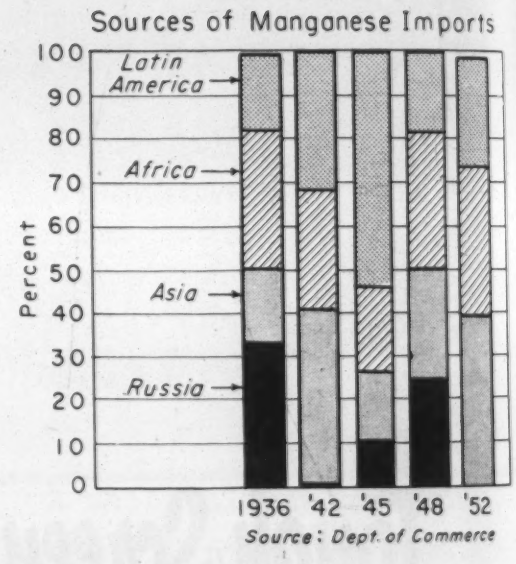
A possible use of manganese as a substitute for critically short nickel has attracted considerable attention recently, and may possibly result in further increase in demand for the metal.

In 1952 the U. S. imported a record 969,000 net tons of contained manganese from sources in 19 countries. However, India, Union of South Africa, Gold Coast, Cuba and Brazil, the five primary sources, contributed over ¾ of the total. Well over half of the imported manganese was consumed in the ferromanganese furnaces of the steel industry.

With only two primary sources of manganese in the Western Hemisphere and no current domestic source worth exploiting, the U. S. is dependent on Africa and Asia for more than 2/3 of current imports. The uncertainty of long-range future supply in the face of unstable world conditions accents the need for a dependable domestic source. As late as 1948, 25% of the manganese consumed in the U. S. came from behind the iron curtain. Now, that market is completely scratched, and although imports from the free world have more than replaced Russian sources, the remaining basic sources of supply are narrow enough to be considered critical.

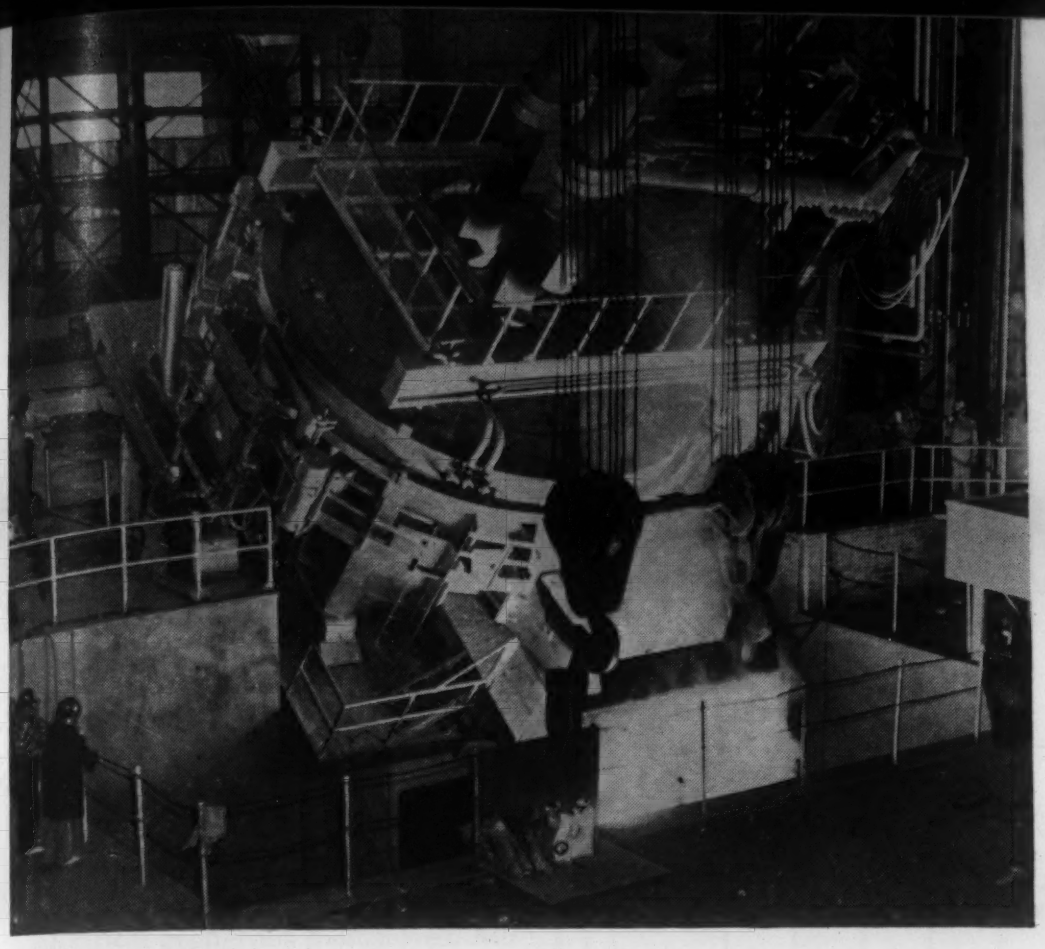
New recovery methods are not yet proven on a commercially competitive basis, but they do offer good basic insurance against critical shortages in time of national emergency.





2nd Basic Materials Show Scheduled for May '54

The Second Basic Materials Show will be held at the International Amphitheater in Chicago, Illinois May 17 through 20, 1954. Exhibitions and meetings will be held concurrently. The second exhibition was originally scheduled for September 1954, but plans were changed to May due to general demand and better arrangement possibilities.



Low carbon steel can be produced economically in modern high-capacity electric furnaces such as this 100 ton installation.

More Electric Furnaces Produce Carbon Steel

Survey Compares Cost

A trend toward carbon steel production in electric furnaces is evident in production figures released for the first five months of 1953. Of electric furnace output in that period, 52% was carbon steel. Total output was 4.2 million tons of ingot and casting steel, amounting to 7.3% of all steel made in the period.

In light of the fact that until the last few years electric furnace output was devoted entirely to production of special alloys, the sudden emergence of electric furnace production as a factor in the total steel supply may come as a surprise. On examination, it is evident that several factors have combined to encourage the use of electric furnaces for carbon steel production.

Rapid post-war technological improvements in electric furnace design have increased capacity and lowered costs to the point where electric furnace costs are comparable to open hearth. Excess electric furnace capacity encountered after the war and early post-war high demand period, induced many steel plants to put electric capacity to work producing open hearth grades of steel. Evidently the practice has paid off.

According to recent results reported from research conducted by the Batelle Memorial Institute for a number of electric utilities and Bituminous Coal Research, Inc., the latest electric furnaces may be more economical than open hearth installations in many instances.

Highlights of the report include claims that:

1. Electric furnaces require only 60% as much capital investment as open hearths.
2. Electric furnaces produce cold-melt steel at less cost and equal open hearths in 50% scrap 50% hot-metal processes.
3. Less than full-capacity operation tends to favor electric furnaces due to lower fixed costs.
4. Rebuilding time is shorter for electric furnaces. Down time is only 15 days a year compared to 30 for open hearths.
5. Electric furnaces give better sulfur control for deep drawing and welding grades of steel.
6. Yield is increased 2% from raw material processed in electric furnaces.

More Titanium Production Ordered

The government is making sure titanium production will continue to rise. Both Du Pont and Titanium Metals Corp. of America, currently in volume production, plan increases. In addition, Defense Materials Procurement Agency recently announced a contract with Cramet, Inc. which will result in "the biggest titanium operation undertaken in the government-industry expansion program." The contract calls for production of 30,000 tons of titanium sponge over a five year period. The government will have 7500 tons of the metal under option and is guaranteeing a $5 per lb minimum price for the first year of production and a $4 minimum for the balance of the contract. The government is also obligated to buy up to 6000 tons of titanium at the option of Cramet during the life of the contract.

The new $25,000,000 plant, for which the government is advancing Cramet $24,950,000, will nearly double government-contracted titanium capacity.

Titanium Corp., now in partial production on an 18,000 ton contract, expects to be in full production at the rate of 3600 tons per year sometime this fall. Du Pont is currently producing 900 tons annually and is scheduled to increase production rate to 3600 tons by 1955. The Cramet Plant is scheduled to produce 6000 tons per year and should be in production by 1956.

Two years ago, the annual production of titanium was a scant 75 tons. Present government contracts call for an annual production rate of 13,000 tons by 1956, and the DMPA reports that additional titanium capacity is expected from private facilities in the near future.

New Lab. Studies Porcelain Steel

Porcelain enameling characteristics of steel will be studied in a new branch of the Research and Development Laboratory of U. S. Steel. The laboratory is equipped for sag testing, pickling and enameling samples

of special and production steels to determine their characteristics under various commercial enameling procedures.

Steel specimens are sag tested in the unenameled state to ensure isolation of the steel characteristics. Controlled atmosphere and firing temperatures from 1300 to over 1600 F can reproduce the conditions of any porcelain fusing operation.

Pickling facilities are designed to duplicate the surface treatment practices of commercial enamelers and to study the effect of surface treatment variables on the enameling characteristics of the steel. Equipment for surface preparation by sand, corundum and shot blasting is also available.

Special and commercial enamel is formulated under carefully controlled conditions and the samples may be either sprayed or dipped. Final firing is done in a furnace under controlled atmosphere and temperature conditions that can be varied to conform to commercial or experimental conditions. Maximum firing temperature is 2000 F.

The laboratory will permit U. S. Steel to isolate the factors in various steels that effect enameling characteristics, as well as the effect of enameling procedures on the strength and other properties of the steel.

Extruded board emerges from delivery end of 24 in. extrusion press. Switch under engineer's hand actuates automatic cut-off and stacking sequence.

Wood Waste Utilization:

Wood Extrusion Press Makes Lower Cost Material

Resin bonded wood-chip panel board will be available in large quantities at low cost if wood processors take advantage of a new series of panel board extrusion presses designed and manufactured by the Chipcraft Co., Morristown, Tenn. The presses chew up wood waste usually headed for the boiler firebox and spit out a continuous sheet of finished board suitable for corestock, flooring, and other uses.

The presses are installed as complete units including wood shredder, conveyors, grading screens, automatic feed unit and cut-off saw. Prices begin around $70,000 for a press with a daily production capacity of 6000 sq ft. Larger presses are available or the smaller ones may be ganged to feed from the same shredder-grader installation. Operated by a single semi-skilled employee and requiring only 3000 sq ft of floor space, the units are of practical size for in-plant installations, and are particularly adaptable to situations where the board is channelled back to the manufacturing operation.

The board, extruded in ½ to 1 in. thicknesses and 24 or 48 in. widths, can be worked with all woodworking tools, can be glued, nailed, dowelled or screw fastened, and

(Continued on page 192)

What They Said . . . .

TEAMWORK "No one person can excel in product design, manufacturing, cost analysis and material procurement, all of which contribute to the proper selection of materials. It requires teamwork to coordinate the efforts of a group of specialists in order to get the most out of materials."—*Theodore A. Jagen, Hyatt Bearing Div., General Motors Corp., June 18, 1953.*

CORROSION "Given the required support and tools to work with, any good corrosion engineer should be able to effect savings that will amount to at least ten times his salary each year."—*F. L. LaQue, The International Nickel Co., Inc.*

ALLOY SAVING ". . . An indication of savings in steel alloying constituents is given by the experience of three companies producing a total of about 30,000 tons per year of ingot steel for tools, heavy-duty gears, shafts, bolts and studs. By using an estimated 1800 lb of boron annually, the net savings per year was 656,000 lb of nickel, 119,000 lb of chromium, 52,000 lb of molybdenum and 9100 lb of manganese."—*Clyde Williams, Director, Battelle Memorial Institute, June 1953.*

DESIGNING WITH ALUMINUM

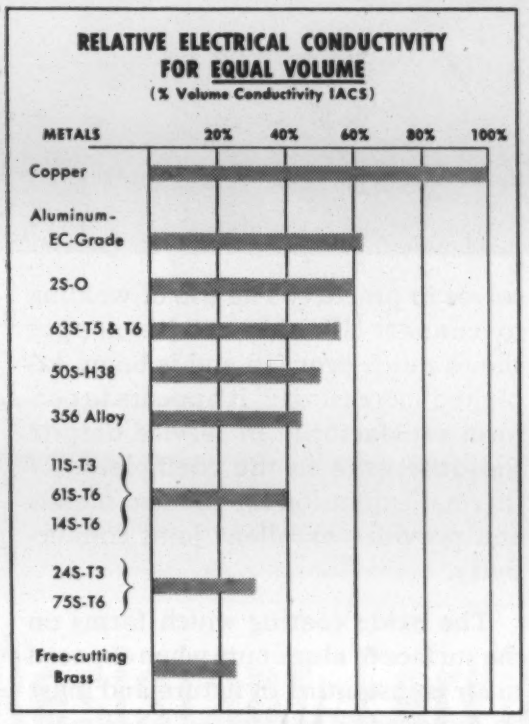
This is one of a series of information sheets which discuss the properties of aluminum and its alloys with relation to design. Extra or missing copies of the series will be supplied on request. Address: Advertising Department, Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

NO. 3 ELECTRICAL CHARACTERISTICS

HIGH CONDUCTIVITY-WEIGHT RATIO OF ALUMINUM ALLOYS USEFUL IN VARIED ELECTRICAL APPLICATIONS

USEFULNESS of a material for electrical applications depends substantially on such considerations as cost, availability, strength, weight, workability, and permanence as well as upon the electrical properties themselves. Aluminum ranks well in all factors, and as a result finds many electrical uses besides those in the field of power transmission and distribution, where it occupies a commanding position.

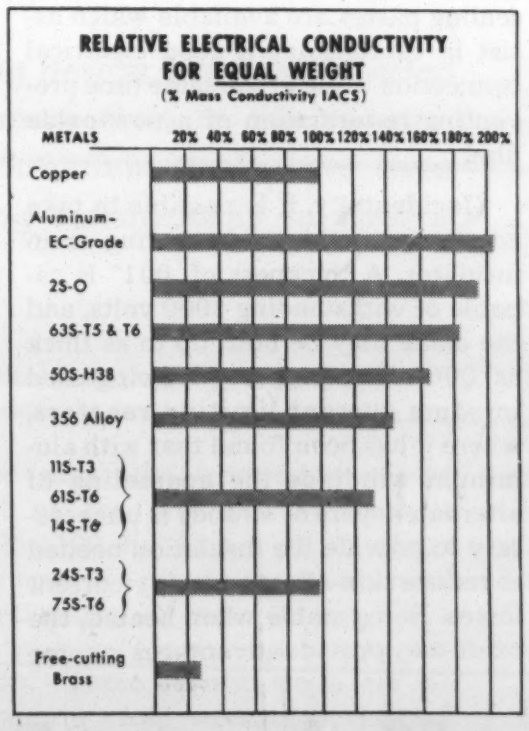
Per pound and per dollar, aluminum can deliver more electrical energy than any other material. Aluminum of EC (Electrical Conductor) grade, hard drawn (H19 temper), has a minimum conductivity of 60.97% of the International Annealed Copper Standard on the basis of *equal volume*, but its conductivity is *204% for equal weight*. In wire and cable design, volume conductivity is the factor commonly used. But in other electrical applications the mass conductivity may be more important.



Aluminum alloys also have good conductivity

The values above apply to metal of 99.45% minimum purity. But it is worth noting that practically all aluminum alloys have good electrical conductivity, especially on the basis of *equal weight*—a circumstance which may well be utilized advantageously in the design and manufacture of electrical equipment, fittings and parts having other requirements in addition to electrical conductivity.

Conductivity decreases with the addition of various alloying elements, but to a less degree than might be expected. The accompanying bar charts illustrate the relative conductivity of a number of widely used alloys on both the volume and weight bases. While they do not imply specific recommendations for electrical applications, the charts show graphically that



on a comparative basis most commercial alloys of aluminum possess good electrical properties.

The alloys charted include representative non-heat-treatable and heat-treatable types of wrought and casting alloys, and all standard forms of aluminum mill products—sheet, plate, rod, bar, wire, forging stock, extrusions and casting ingot. Their availabilities are as follows:

ALLOY	
EC	Sheet, plate, wire, conductor, bus bar.
2S	Sheet, plate, rod, wire, forging stock, extrusions.
63S	Extrusions.
50S	Sheet, plate.
356	Casting ingot.
11S	Rod, bar, wire.
61S	Sheet, plate, rod, wire, forging stock, extrusions.
14S	Sheet, plate, rod, wire, forging stock, extrusions.
24S	Sheet, plate, rod, bar, wire, extrusions.
75S	Sheet, plate, forging stock, extrusions.

These alloys include a range of tensile strengths up 83,000 psi for 75S-T6, the strongest commercially produced aluminum alloy, which on a *weight* basis has practically equal conductivity with copper. The tensile strengths of several other heat-treatable alloys are also greater than that of hard-drawn copper.

Also, a cable or bus bar of EC aluminum, having a tensile strength of 27,000 psi, will have a total breaking strength in tension close to that of a copper cable or bus of equivalent resistance because of the somewhat greater cross-sectional area required. An aluminum bus will have greater bending strength because of the increased section modulus.

The greater peripheral area of an EC aluminum conductor of equal resistance to a copper conductor means that it will dissipate more heat at a given temperature. This, combined with a lower inherent skin-effect, gives the aluminum conductor a current carrying capacity which varies from

PLEASE TURN TO NEXT PAGE ➡

78% to 84% (depending on size) of the same-size copper conductor.

Present applications suggest future uses

The progress made in recent years in successful electrical applications of aluminum indicates an accelerating rate of development. Thousands of fractional horsepower motors have been and are being produced with aluminum magnet wire stator windings. Some changes in manufacturing techniques were required, but no serious problems were met in actual practice, including aluminum-to-copper connections where they were required.

Similarly aluminum wire is being used, and giving good performance, in transformer windings and discharge lamp ballasts. Use of aluminum has even made it possible to build larger turbine driven generators than ever before because of its combination of light weight and good conductivity, permitting higher rotor speeds without exceeding safe centrifugal force limits.

Aluminum sheet is standard material today in the manufacture of electric light bulb bases and lamp sockets. The alloys generally used have a volume conductivity of 42% and 35%, respectively. Aluminum in these applications has better conductivity than brass, is more economical and is easily fabricated.

Cast aluminum is regularly used in the rotors of induction motors, with lower costs for both metal and fabrication. An important additional advantage is that cooling fans may be cast integrally with rotor bars and collector rings. Aluminum rod and bar (screw machine stock) are used for battery terminals, and similar applications.

Because it provides a high ratio of area to volume by being rolled to extremely fine gauges, aluminum foil is standard in capacitors. The surface area is generally increased further by etching the foil.

Connections for aluminum

Different types of connections and different techniques are employed with aluminum. Though not all problems have been solved yet, the important fact is that satisfactory connectors and methods for aluminum-to-aluminum and aluminum-to-copper connections are available and have proved themselves in practice. The use of welding to connect aluminum with copper shows much promise and is being exploited increasingly; it appears to perform satisfactorily in service despite the difference in the coefficients of thermal expansion for the two metals and provides excellent joint conductivity.

The oxide coating which forms on the surface of aluminum when exposed to air is insulating in nature and must be removed or penetrated when making a connection. Suitable contact and sealing pastes are available which assist in establishing a good electrical connection while at the same time preventing re-formation of a new oxide film.

(Incidentally, it is possible to take advantage of this oxide coating as an insulator. A thickness of .001" is capable of withstanding 1000 volts, and the oxide may be built up to as thick as .006". This property is being used in some current-limiting reactors, where it has been found that with aluminum windings the enameling of alternate layers of strands is unnecessary to provide the insulation needed to reduce skin-effect and eddy-current losses. Being stable when heated, the oxide may provide advantages in some applications over other normally used coverings such as organic coatings.)

Savings offer strong aluminum inducement

With its characteristics of less weight and substantially lower per pound cost, the savings in metal costs through the use of aluminum present an opportunity for substantial economies. In some cases, it is true, manufacturing costs may rise somewhat until techniques are developed, but seldom enough to wipe out the metal saving. On the other hand, economies in fabrication, handling and shipment will undoubtedly be achieved.

It is important also that the price of aluminum is relatively stable and that expanding aluminum production is steadily increasing its availability.

The broad advantages that aluminum offers in electrical applications are well worth investigating. Services of experienced Kaiser Aluminum engineers are available for consultation and assistance on your design and manufacturing problems. Call the nearest Kaiser Aluminum sales office or write Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

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Advantages

1. Higher proof and maximum stresses at low temperatures — very useful under cold starting conditions.
2. Better creep resistance properties at lower temperatures.
3. Higher thermal conductivity.
4. Lower coefficient of thermal expansion.
5. Greater ease in machining.
6. Large forgings more easily produced.
7. Lower cost — about one quarter to one half that of a similar sized austenitic part.

and Disadvantages

1. Reduction in strength on overheating occurs to a greater degree.
2. Susceptibility to a major change in mechanical properties on overheating is greater for a hardened and tempered component than for one fully austenitic over the whole working temperature range.
3. The uniformity of ferritic disks in mass production is estimated to be lower.
4. Greater liability in hardened and tempered components to suffer from segregation and hairline cracks.
5. Weldability of the more highly alloyed steels is poor. Even if welding can be satisfactorily carried out, complete retreatment of the whole structure is required.

New Creep Resistant Ferritic Steels

In Britain and Europe, engineering design has been directed towards the use of ferritic steels more than in this country. As a result, modified 10 to 12% chromium steels have been developed that are now performing satisfactorily in service.

by **DAVID D. HOWAT**, The Royal Technical College, Glasgow, Scotland

● ALTHOUGH the thermal efficiency of gas turbines increases with temperature, the difficulty of obtaining suitable heat resisting alloys also increases. For this reason it may prove better to accept a lower temperature level which will permit the use of less critical ferritic steels.

To help meet high temperature problems, design has been focused on the effort to utilize higher gas temperatures with protective air cooling for critical parts of the turbine. As a result, although gas temperatures of 1375 F or higher prevail at the turbine entry, the temperature at the rim of the disk can be kept to 1025-1100 F. This trend in design has been of critical importance in the development of new ferritic alloys, particularly for turbine rotors and disks. These ferritic steels are superior in creep strength at 1100 F to those austenitic steels available at the beginning of jet development in 1940.

The development of ferritic creep resistant steels can be divided into two stages: 1) the relatively simple steels for use in superheater tubes and for power generation in general; 2) the production of steels suitable for use in gas turbines.

In the first group the mechanical properties demanded by the design engineer are stringent, calling for exact and carefully controlled heat treatment. On the other hand the service temperatures are not unduly high—maximum about 1025 F at the present time—and scaling resistance is not a major problem. In this group of steels which includes molybdenum, chromium-molybdenum and molybdenum-vanadium steels, the carbide phase is relatively simple, control of the distribution and rate of precipitation of the carbides being dependent upon the heat treatment. Extensive, long-term investigations of this group of steels have been carried out by Glen who has shown the great importance attaching to the heat-treatment in the development of the maximum creep resistance.

In the gas turbine field operating conditions are more severe. The serv-

ice temperatures are higher and scaling resistance becomes a major factor and a delicate balance must be struck between creep resistance and scaling resistance. Steel of increasingly complex composition have been proposed. Identification of the precipitating phase becomes more difficult and the conditions for securing the correct dispersion of the carbide phase and its rate of precipitation become increasingly critical.

The advantages and disadvantages of using ferritic steels in place of austenitic steels for gas turbine parts such as disks and rotors are summarized in an accompanying table. Bailey expresses the opinion that ferritic disks have a further advantage in that the average stress at bursting corresponds with the normal tensile strength of the material. With austenitic steel disks the bursting stress is only 72 to 80% of the normal tensile strength. The higher proof and maximum stresses of the ferritic steels therefore confer these additional advantages.

Development of Ferritic Steels for Gas Turbines

Molybdenum and molybdenum-vanadium steels proved a starting point for the development of ferritic steels capable of withstanding the more exacting conditions of the gas turbine. Kirby and Sykes state that although the molybdenum-vanadium steels have a useful creep strength up to 1100 F for short time service in jet engines, for long term service, 100,000 hr, the temperature of operation is limited to 975 F. Further, Glen has recently described the remarkable effects obtained by the introduction of titanium into a molybdenum-vanadium steel. This is brought out strikingly by a comparison. At 1110 F and under a stress of 13,400 psi the plain molybdenum steel reaches 0.1% creep in strain in 10 hr; the molybdenum-vanadium steel shows the same creep in 500 hr, but the molybdenum-vanadium-titanium steel takes about 20,000 hr. Under the given conditions this steel compares favorably with an 18:8 chromium-nickel steel with about 1% columbium.

The principal disadvantage of these simple and relatively cheap ferritic steels is poor scaling resistance. Extensive work is in progress in Britain to develop methods of improving scaling resistance, the most promising being the formation of a chromium surface layer by gaseous deposition.

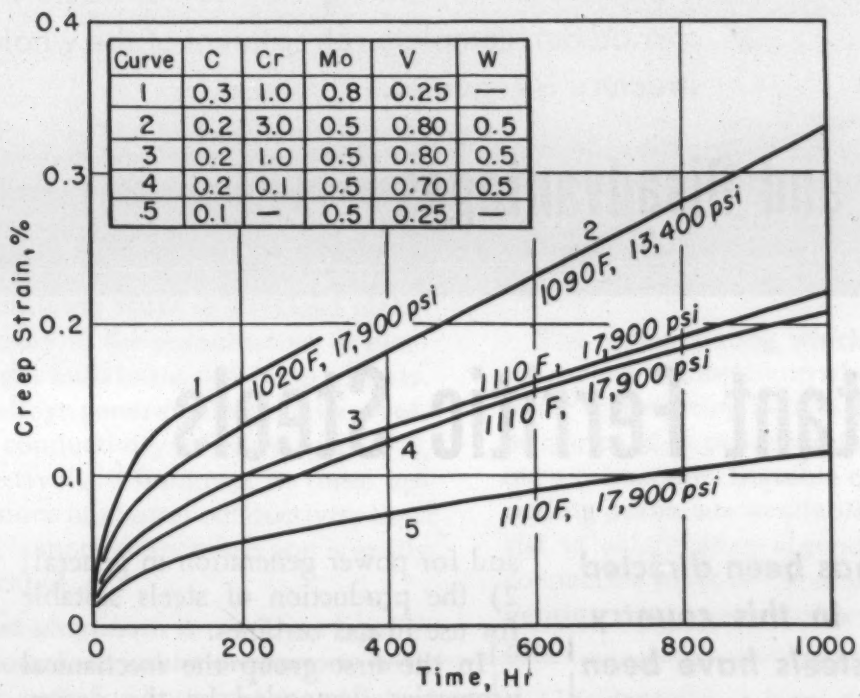

Fig 1—Improvement in creep resistance obtained by adding chromium and tungsten to molybdenum-vanadium steels. (Ward and Rait)

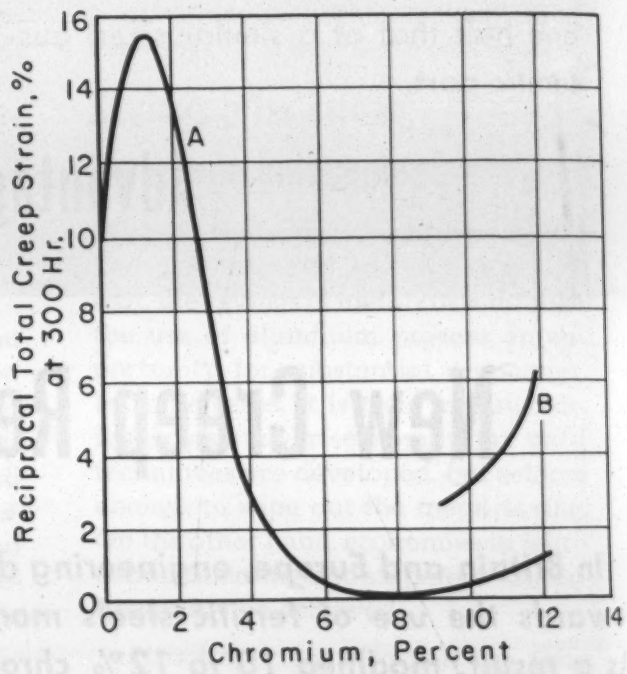

Fig 2—Effect of chromium additions on the creep properties. (Colbeck and Rait)

A. Base composition 0.2 C, 0.5 Mo, 0.8 V, 0.5% W.

B. Base composition 0.2 C, 0.5 Mo, 0.8 V, 0.15% Cb.

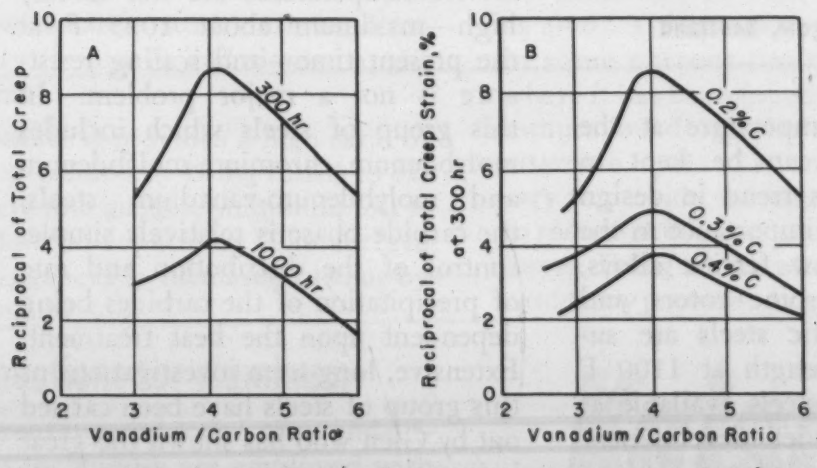

Fig 3—Effect of vanadium/carbon ratio on creep properties determined at 17,900 psi and 1110 F. (Ward and Rait)

A. Base composition 0.2 C, 3 Cr, 0.5 Mo, 0.5% W.

B. Steel of type 3% Cr, Mo, W, V.

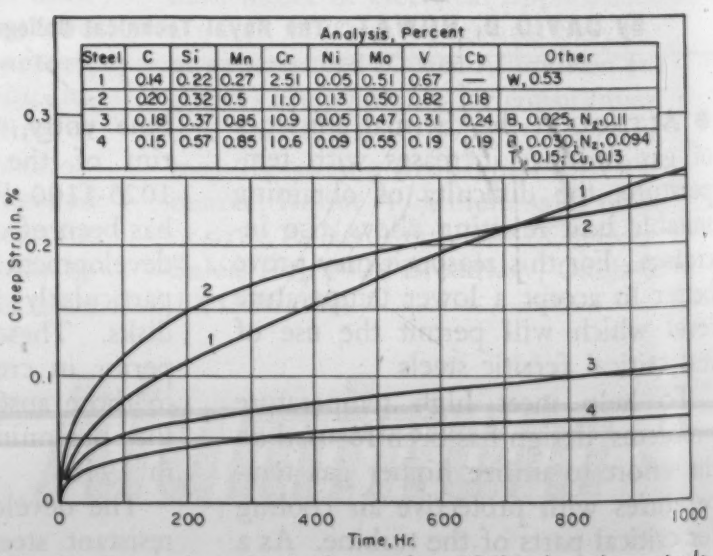

Fig 4—Creep properties of complex 12% chromium steels. (Ward and Rait)

Table 1—Influence of Chromium on Creep (Ward and Rait)

Steel Number	Composition, %					Creep Strain, %		Reciprocal of Creep Strain, %		Carbides Present in Electrolytic Residues
	C	Cr	V	Mo	W	300 Hr	1,000 Hr	300 Hr	1,000 Hr	
1	0.18	0.06	0.70	0.69	0.67	0.103	0.21	9.70	6.76	—
2	0.19	1.01	0.63	0.57	0.63	0.065	0.124	15.60	8.05	VC
3	0.18	2.79	0.68	0.50	0.59	0.113	0.227	8.85	4.40	VC
4	0.19	4.70	0.74	0.55	0.63	0.65 (170 hr)	3.94	1.54	0.254	Cr_7C_3 ($Cr_{23}C_6$)
5	0.17	6.85	0.79	0.54	0.58	2.57 (140 hr)	—	0.4 (140 hr)	—	$Cr_{23}C_6$
6	0.20	8.90	0.79	0.49	0.60	1.60 2.8	—	0.36	—	—
7	0.19	10.10	0.71	0.51	0.60	1.70	6.0	0.59	0.16	—
8	0.14	11.65	0.81	0.55	0.65	0.89	2.11	1.12	0.474	$Cr_{23}C_6$ (Cr_7C_3)

Note: Tests run at 18,000 psi and 1110 F.

Working largely on an empirical basis, a study was made of the effects of additions of chromium and tungsten to these molybdenum-vanadium steels, some of the data obtained being shown in Fig 1. One of the earliest, and still a highly useful steel for gas turbine work, is the 3 chromium, 0.5 molybdenum, 0.5 tungsten and 0.75% vanadium steel (3% Cr-Mo-W-V). Developed originally in Germany where it was also employed in oil-cracking plants because of its resistance to hydrogen embrittlement, this steel was first introduced into Britain in 1945. Properties of this steel given by Colbeck and Rait are: good hot strength, (see curve 2 in Fig 1), high degree of stability under long time heating, reasonable scaling resistance up to about 1100 F and satisfactory forgeability and machinability.

The only advantage of increasing the chromium content of these steels is improved scaling resistance. Colbeck and Rait carried out a series of tests showing the effects of variations in content on the creep properties of steels with constant carbon, molybdenum, tungsten and vanadium contents. As shown in Fig 2, the creep resistant properties pass through a maximum at 1% chromium and then fall rapidly with increase in the chromium content, passing through a minimum at about 8% and thereafter showing a slow improvement. Data relating to the influence of chromium on the creep properties and on the main types of carbides present in the steels are shown in Table 1. From these data it is obvious that the only advantage of 3% chromium over 1% is enhanced scaling resistance, which is obtained at the expense of creep resistance.

Variations in the creep properties with different heat treatments convinced Colbeck and Rait and Ward that the nature and distribution of the carbides in the 1% and 3% chromium - molybdenum - vanadium - tungsten steels are paramount considerations. Various tests carried out on these two steels showed a maximum in creep resistance with a vanadium/carbon ratio of 4:1. The results shown in Fig 3 also showed that increase in the carbon content above 0.2% adversely affected the creep resistance.

Development of 12% Chromium Steels

The creep resistance of the 1 and 3% Cr-Mo-W-V steels is superior to the scaling resistance; therefore, there is a demand for a steel with comparable or even superior creep resistance and improved scaling re-

Needed: More Knowledge on Creep

At the present time a most serious drawback is the lack of adequate fundamental knowledge of the mechanism of creep in steels and of those characteristics which confer high temperature strength. It appears that creep may occur by at least two principal processes: first, by general slip within the grains; second, by viscous or quasi-viscous flow at the grain boundaries. Among the factors which may affect the creep resistant properties are therefore, a) grain size, b) the distribution of the addition elements between the solid solution matrix and the carbide phase and c) the composition and dispersion of the precipitated carbide phase.

Although there is distinct evidence that both processes of creep operate, the influence of grain size appears to be of comparatively secondary importance. Rotherham states that the magnitude of the change which could be caused by simple grain size alterations is not likely to be great in relation to the other changes which are possible. In addition, the introduction of a coarse grain structure into a metal may be regarded as undesirable from a number of metallurgical and engineering considerations. Betteridge suggests that a coarse grain size is advantageous only when the grains themselves are sufficiently rigid for grain deformation to proceed only slowly, and that, given such grains, the creep rate is largely controlled by the rate of flow of the boundaries, that is, by their viscosity. Glen's results, however, indicate that grain size may be rather more important. He shows that the use of aluminum and silicon as deoxidizers results in refining the grain structure giving poor creep properties at high temperatures.

Investigation of the other two factors affecting creep properties are more difficult. The empirical approach has shown that steels resistant to creep are extremely complex. Structural studies are not easy and it is difficult to give any indication of the inherent structure or characteristics producing this particular property. About the only definite statement possible is that the best creep resistance is generally found when the material is slightly unstable; that is, when precipitation can occur slowly. The precipitation of certain types of compounds at suitable rates and in a certain degree of dispersion is essential to good creep resistance. If this proves to be the case then the addition elements control the creep properties largely through their influence on the precipitating phase and not on the matrix solid solution itself.

Table 2—Effect of Composition on Creep of Various Steels (Oliver and Harris)

Type of Steel	Composition, %							Creep Strength for 1% Strain in 300 Hr	
	Cr	C	Si	Mo	W	V	Ni	1110 F	1200 F
Non-stainless	6.0	0.6	1.2	0.5	—	—	—	6,300	—
Non-stainless	1.1	0.4	0.3	0.7	—	—	—	14,200	11,200
Non-stainless	3.0	0.25	0.4	0.5	0.5	0.75	—	31,300	17,900
Stainless	12.0	standard	standard	standard	standard	standard	standard	4,500–6,400	—
Stainless	11.0	0.2	0.3	0.5	—	0.7	0.15	31,300	22,800

sistance at about 1200 F. The data in Fig 2 show that additions of chromium in excess of 1% to a base containing 0.2 carbon, 0.5 Mo, 0.5 W, and 0.5% V result in a very marked reduction in creep resistance. Thus, considerable modification in chemical composition is imperative if the good scaling resistance of the 12% chromium steels is not to be offset by poor creep resistance.

After a great deal of development work on these 10 to 12% chromium steels, much improved types are being produced for gas turbines. Oliver and Harris have indicated the progressive improvement in creep resistance secured in these newer types of steels. These authors also quote figures for a newer type of 12% chromium steel with a creep strength of 40,000 to 42,000 psi at 1110 F for 1% strain at 300 hr.

The latest paper by Ward and Rait gives further information on the composition and properties of these improved 12% chromium steels. The first point is that columbium can be substituted for tungsten with an improvement in creep resistance as indicated in curve B in Fig 2. It has also been shown that creep resistance is considerably improved by high temperature treatment at about 2275 F.

No vanadium carbide was found in the carbides extracted from these steels and it was shown that the vanadium content can be considerably reduced and additional columbium used. When using reasonably high niobium contents the carbide formed in the steel is found to be $Cr_{23}C_6$. The authors point out that a steel containing this carbide has considerably better creep resistance than one containing the carbide Cr_7C_3, which is the carbide found normally in 12% chromium steels with low columbium content.

Table 3—High-Temperature Creep Data on Improved 12% Chromium Steel (Kirby and Sykes)

Creep Deformation	Stress, Psi at:		
	1020 F	1110 F	1200 F
0.2% in 300 hr	—	31,400	19,000
0.5% in 300 hr	—	38,100	13,500
Fracture in 300 hr	62,700	40,300	30,300
0.2% in 1,000 hr	—	22,400	15,700
0.5% in 1,000 hr	—	33,600	17,900
Fracture in 1,000 hr	58,200	38,100	22,400

Ward and Rait also emphasize the necessity of preventing the formation of delta ferrite. They assure that delta ferrite is undesirable as it is frequently associated with bad carbide segregation and in consequence with impaired creep resistance. The tendency toward the formation of delta ferrite can be partially avoided by the use of austenite formers, such as manganese, nickel or nitrogen. Nitrogen has proved satisfactory and a commercial steel of the 12% chromium-molybdenum-vanadium columbium nitrogen type is available.

The addition of boron and titanium to these 12% chromium steels has brought about a considerable improvement in the creep resistance. As shown in Fig 4, a 12% chromium-molybdenum-vanadium-columbium steel containing 0.03 boron, 0.09 nitrogen and 0.15% titanium, when tested at 1110 F under a stress of 18,000 psi shows a creep strain of 0.075 in 1,000 hr, or about one quarter of the creep strain shown by a similar steel containing no boron, nitrogen or titanium. From the analyses quoted in Fig 4 it is obvious that the trend is toward lower vanadium content, the small quantities of titanium appearing to play a very important part.

Several types of these improved 12% chromium stainless steels are available from different manufacturers, all of the products having comparable creep resistance. An accompanying table gives data on one example of an improved 12% chromium stainless steel as reported by Kirby and Sykes.

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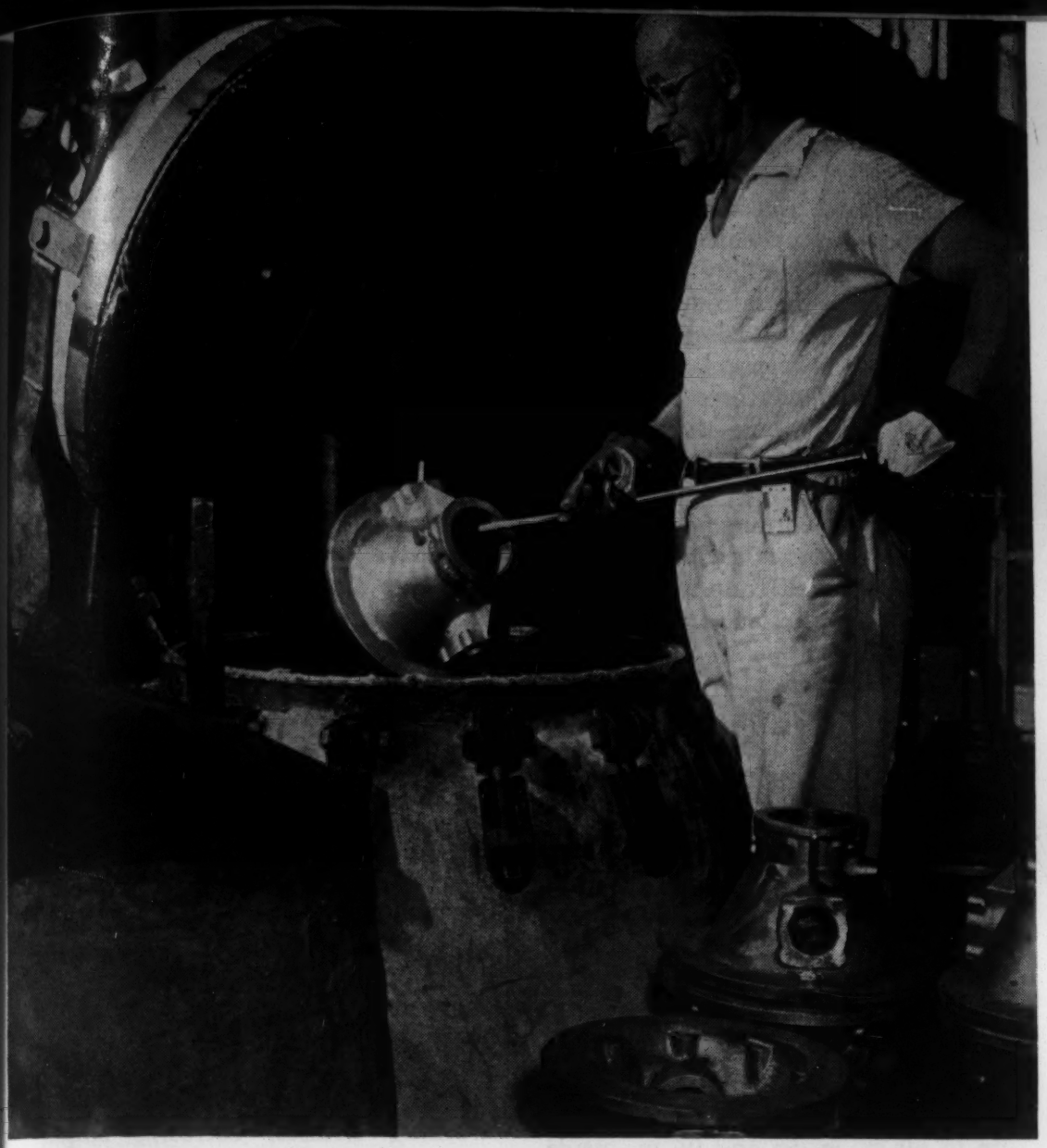


Magnesium gearbox housings (above and below) are vacuum impregnated at York Gears Ltd., using a synthetic resin-type impregnant.

Vacuum Impregnation Makes Porosity-Free Castings

By filling micro-voids with one of many different kinds of impregnants, more serviceable castings are obtained. Also, fewer rejects, and savings in time and material result.

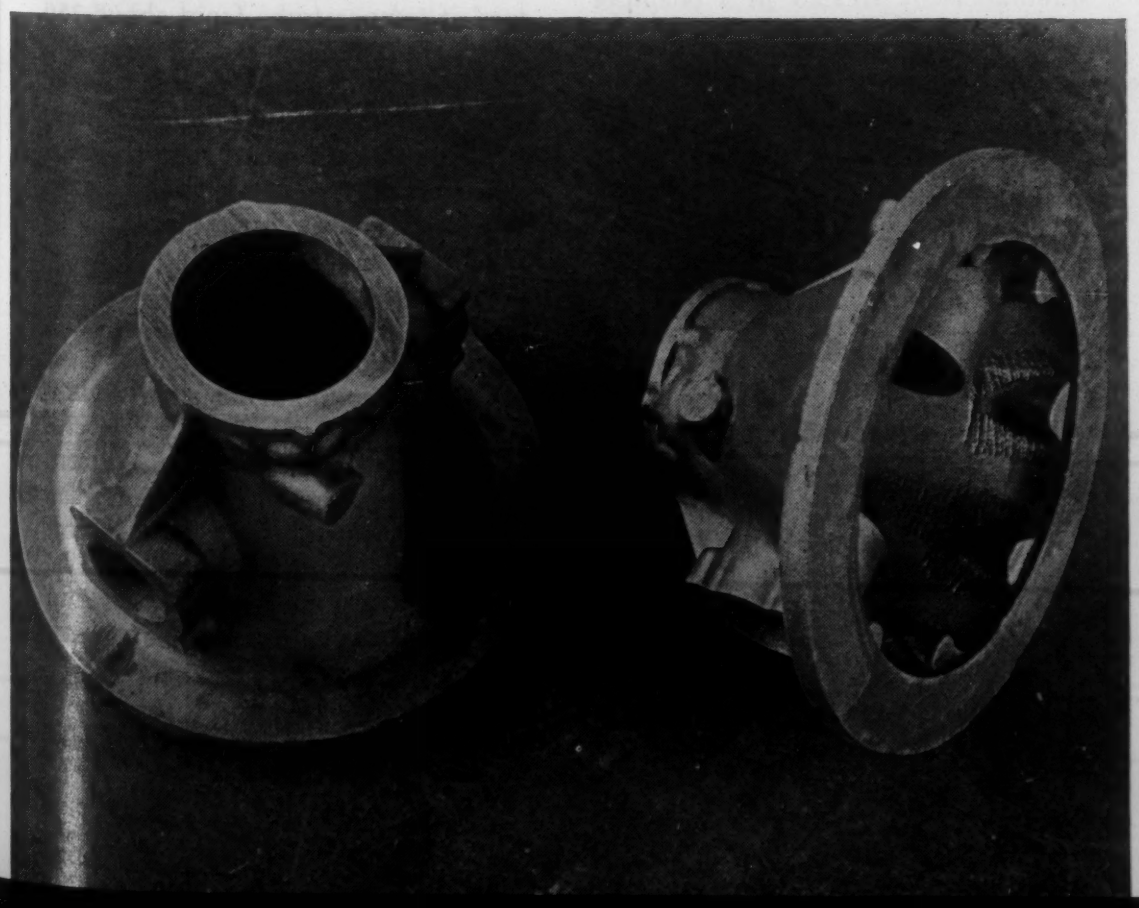
by JOHN H. LEARY, Manager,
Vacuum Impregnating Dept.,
F. J. Stokes Machine Co.

● POROSITY MIGHT NOT be a fatal flaw in every product, but in most engineering materials it is highly undesirable.

In metal castings, porosity is not only a source of mechanical weakness, but can eventually lead to structural failure. In certain kinds of components, porosity can also prevent the proper fulfilment of their design function. Pressure-type castings, for instance, that must retain gases or liquids under high operating pressures in the assembled unit, may be rendered wholly unacceptable by micro-porosity. Most components must be free of porosity if they are to serve their intended purpose in such exacting service as jet engine compressor casings, supercharger blower housings, cylinder heads, crankcases, gear-train boxes, carburetors, fuel pumps and meters, hydraulic pump bodies and transformer tank covers.

Vacuum impregnation is now a well-developed and accepted procedure for correcting porosity in castings and offers, therefore, a method of reducing total material costs by producing more satisfactory castings, fewer rejects, and savings in time. The process is primarily useful for correcting capillary defects in castings; it is not suitable for reclaiming castings with large visible voids and porosities which would permit spurting under hydraulic pressure.

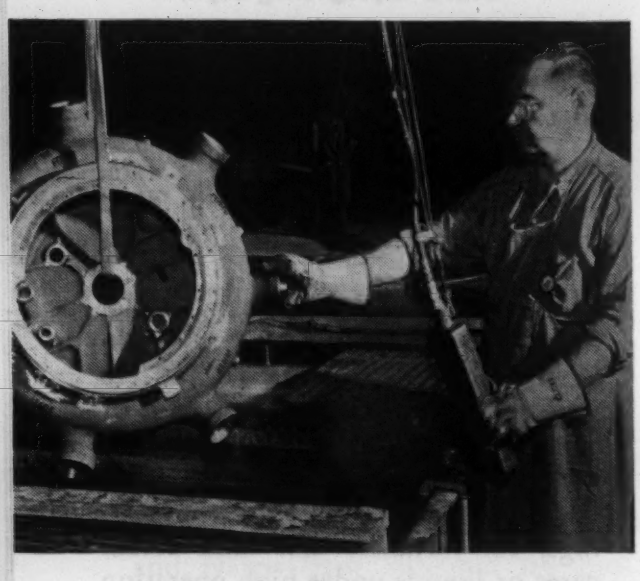
Impregnation yields stronger castings, as a result of filling the tiny voids with a material that bonds integrally with the metal and is itself strong, non-fusible, and non-oxidizing. Impregnated components are less likely to develop voids in service than untreated castings where discon-



nected pores might under stress open up and join others.

Impregnation usually produces a better base material for plating, where this is to be done, not only on castings, but also on formed shapes and powdered metal parts. By penetrating all the pores and filling up the voids it prevents any post-plating exudation of the sub-surface treatment which might deteriorate the plating and spoil the finish.

Several methods of pressure impregnation *without vacuum* have been used for some time for sealing metal castings. But all these methods have the obvious defect that air is trapped in the capillary passages and compressed by the introduction of the impregnant under pressure. When the pressure is released, this air will again expand and force the impregnant out of some of the pores and to that extent defeat the purpose of the process. Even though solid bridges of the impregnant do form over other pores, they are liable to rupture in service, from wear, solvent action, or (with some impregnants) electrolysis.



Casting of collector for Pratt & Whitney Aircraft Double Wasp engine is thoroughly cleaned before vacuum impregnation.

Aircraft engine castings ready for impregnation to make them leakproof.

What Sizes Can Be Impregnated?

Experience in a wide range of industries has shown that there is virtually no limit to the size of parts which can be satisfactorily vacuum impregnated. The only apparent limitation is the size of the available impregnating chamber, which in turn may depend upon the volume of impregnating to be done and manufacturer's willingness to invest in such equipment. Standard vacuum impregnating chambers are available up to 60 in. in dia and 96 in. inside height. Larger units, which may have to be shipped in sections and assembled on the site, can be built as special order equipment.

Examples of very large parts that have been successfully vacuum-impregnated are transformer tanks and covers, jet engine diffusers, hydraulic pump housings and cylinders, and main generator armatures for diesel-electric locomotives. General Electric Co. of Canada uses one of the largest impregnating chambers known, rectangular in shape, 12 ft by 18 ft by 24 ft, for impregnating large transformers.

The number of parts which can be simultaneously treated in a chamber is limited only by the cubic capacity of the chamber. The length of the impregnating cycle is in direct ratio to the cross-section of the individual pieces. To some extent, the duration of the impregnating cycle is modified according to the total volume of parts being treated.

What Type of Impregnant?

Any type of impregnant desired can be applied by vacuum methods, providing that it will flow at moderate temperatures. The materials which are most commonly used for engineering materials are:

Plastic resins: polyesters, phenol-formaldehydes, urea-formaldehydes, and monomeric styrene. These are the ones most commonly used for improving metal castings.

Petroleum derivatives: coal-tar, creosote oil, wax, and greases. These materials are extensively used for preserving wood products because of their low cost and their toxic action against insect and fungus attack.

Chemicals, such as sodium silicate (water-glass): These are widely used but have certain limitations because they are slightly water-soluble; they also present something of a housekeeping and safety problem.

Miscellaneous: graphite, linseed oil, tung oil, etc. Tung oil was perhaps the most widely used preservative until World War II cut off supplies from China to the Western countries, which stimulated the development of the synthetic resin-type impregnants.

In selecting the material for impregnation, the principal considerations must be the same as those which determine the selection of the base material itself: what are the service conditions — temperature, working stresses, corrosive atmosphere, etc.—which will be met? Beyond these factors are the requirements imposed by the treating operation itself: compatibility with the base material, moderate flow-point, non-toxicity, non-explosive, and (preferably) freedom from the need for solvents as a vehicle.

For impregnating castings—both of ferrous and non-ferrous metals—the synthetic resin-type impregnants listed above are widely used. Those that are thermosetting resins are cured by heat and polymerize to form hard, durable fillers. These compounds vary in their properties and in the proportion and type of volatile and resin constituents. They cure at temperatures from about 250 to 300 F in about ½ to 5 hr depending on the compound and on the piece that has been impregnated.

A number of other impregnants which do not require heat for curing but set at room temperature are also being used for impregnating castings. These compounds harden by the evaporation of the solvent without the application of heat.

The styrene monomer resins, when used with copper-base castings, require an additive to stabilize them and prevent interaction with the metal, which would otherwise inhibit polymerization. Also, care must be taken with this impregnant to avoid the use of copper, brass or bronze

fittings in the impregnating tank and piping system.

In general, impregnants should be selected with an eye to their permanence, good penetration of the casting, non-abrasiveness (so that they do not affect subsequent machining operations), relative low-cost, and ability to be handled easily under normal shop practice.

How It Is Done

Vacuum impregnation consists, briefly, of placing the materials to be impregnated in a vacuum chamber in which a high vacuum is then drawn to remove all the air and moisture from the parts. The impregnating liquid is then introduced into the chamber and allowed to cover the work-pieces. Pressure is then built up within the chamber to speed up the penetration of the impregnant into the innermost pores of the parts. Then the materials are removed, dried, freed of any surface film, and (where needed) baked, usually in a separate drying oven, to polymerize or otherwise harden the impregnant.

Vacuum impregnation — like all vacuum processing—is successful to the degree that the vacuum itself is effective, and for this reason the vacuum-producing equipment should be carefully selected and maintained. Absolute pressures as low as 50 microns (equal to 0.05 mm or 0.002 in. of mercury) can now be easily attained and held, even in larger chambers, with present-day vacuum pumps. But the effectiveness of vacuum impregnation is increased in much more than a direct ratio. The results from present equipment, compared to those obtained with the vacuums of only 1 or 0.1 psi absolute, which were the best that could be obtained in common industrial use until a few years ago, can be described only as revolutionary. With the higher vacuum, the materials being impregnated can be evacuated completely and the penetration of the impregnant is virtually 100%.

The complete impregnating cycle involves the following steps:

1. *Degrease*—Rough castings may have to be pickled in a weak (3%) sulfuric acid bath.
2. *Rinse.*
3. *Dry* — Air drying is usually sufficient. Certain components with intricately-shaped recesses may have to be oven-dried to make sure that all moisture is removed. For certain impregnants, the parts may need to be pre-heated before treating.
4. *Load*—Small parts are generally handled in bulk in perforated metal baskets; larger pieces may be loaded individually into the chamber or a number of them may be treated at once, in which case they may be separated by appropriate racks.
5. *Evacuate* — The chamber is closed and a vacuum of 28 in. or better is drawn to remove the air from the pores. This vacuum should be maintained for 20 to 30 min with most parts, and until the gage reading is steady. The degree of vacuum and the duration depends, of course, upon the degree of penetration required and the design of the part.
6. *Immerse* — Without breaking the vacuum, the impregnant is admitted to the impregnating chamber by valving from the storage tank, allowing it to flow in slowly until the parts are completely covered.
7. *Impregnate* — The vacuum is broken and pressure is applied in the chamber either by air or a nitrogen atmosphere depending on the impregnant and built up to from 70 to 90 psi (on very heavy castings the pressure might run as high as 250 to 500 psi) and maintained for 20 to 30 min. This pressure forces the impregnant into the innermost pores of the casting. Then, as the pressure is being reduced, the valve in the impregnant-supply line is opened and the surplus impregnant is forced back into the storage tank.
8. *Drain, clean, and rinse*—The parts are removed from the chamber, drained, cleaned of surface film of the impregnant (if necessary) by a solvent such as denatured alcohol or a soap solution, and then rinsed.
9. *Cure*—Where the impregnant requires heat for polymerizing, the parts are usually placed in a separate oven and baked for 2 to 3 hr, at temperatures from 275 to 300 F, depending on type of impregnant.
10. *Test*—After the cured parts have cooled they are then pressure-tested at specified pressures to prove the tenacity of the bond. Properly executed, the impregnation will be an integral part of the casting.

What Equipment Is Required?

The basic elements of an impregnating system are the impregnating chamber, the vacuum producing equipment, and the impregnant storage tank, with associated cleaning, rinsing, drying, and curing units, and the necessary indicating and recording instrumentation. Manufacturers offer standard units in a wide range of sizes to fit most customers' requirements, and should be consulted for their advice before designing a specific processing installation. Special units can be built at a reasonable cost or standard units can be modified to meet special problems. For example, if the impregnating chamber is also to be used as a dryer, and a steam jacket would provide insufficient heating capacity, electric resistance-heating can be incorporated. Where the impregnant to be used has a high melting point, such as sulfur or certain waxes, the impregnating chamber and the impregnant storage tank would both require electric heating.

For certain impregnants, constant aeration is required in the storage tank; for others, such as solvent-soluble ones and some viscous ones, agitators are required. Other impregnants require heating or cooling coils or jackets on the storage tank, and sometimes also on the impregnating chamber. When impregnating parts which are warm, certain resin impregnants must be kept below 60 F to keep them from setting up, which may require cooling coils or jackets on the storage tank and, if the impregnating cycle is a long one, on the impregnating chamber, also.

Certain very large or irregularly shaped castings which would be difficult to fit into impregnating chambers can be vacuum-impregnated by using the casting itself as the container. The outside of the casting is first sealed, then a suitable cover-plate and gasket are attached, the vacuum is drawn within the component, and the rest of the impregnating cycle is then carried out.

What Does It Cost?

The cost of vacuum-impregnating a casting ranges from 5 cents to 15 cents per pound of casting, depending on the metal, the shape of the component, the quantity processed, and the impregnant used. This is a moderate cost when set against the cost of scrapping an unusable casting, and the true measure of the economy of the process is more apparent when the part has already been partly or completely machined. Custom shops now carry out the work—both regular production and salvage—for a scale of prices that varies according to the total weight of castings processed and that ranges from $10 to $20 per cycle.

PICTURE CREDIT: General Electric Co.

New Vinyl-Metal Sheet . . .

Applications requiring these properties are expected for vinyl-metal laminate. This container is made of the new sheet.

Deep drawn shapes can be made from new laminate without damage to vinyl coating.

Resists Corrosion and Abrasion.....Can Be Formed

by PHILIP O'KEEFE, Associate Editor, Materials & Methods

● A PROCESS HAS BEEN developed by the Naugatuck Chemical Div. of United States Rubber Co. to firmly bond rigid and semi-rigid vinyl film to steel and aluminum sheets. The resulting laminate has the strength of the base metal, plus the corrosion resistance and attractive appearance of the vinyl overlay. Most important of all, the abrasion resistance is better than conventional varnish, phenolic or alkyd finishes. The metal-to-plastic bond is so strong that deep draws can be made from the plastic-metal laminate without puncturing the vinyl covering. Decorative and corrosion and abrasion resistive applications are expected for the coated sheet and strip. In price, it will be below stainless steel, but above galvanized.

The laminate is made by rolling vinyl sheet on adhesive coated metal sheet or strip. The secret of the process lies in the metal cleaning and in the adhesive used. Rolling pressures are not high. The rolling is done at room temperature and the adhesive bond is effected under heat lamps after rolling. The bonding takes place in a matter of seconds. The process lends itself well to high speed production.

Properties

There are no special physical limitations on the metal or the vinyl. So far, cold-rolled steel sheet, hot-rolled pickled steel, and aluminum from 18 to 34 gage have been used. The vinyl films used have ranged from 0.002 to 0.020 in. thickness. White, blue and green vinyls have been used. Any color can be employed, of course, but the properties will vary somewhat with the characteristic of the pigment.

Hardness, elongation and general properties of the coatings can be varied. Rigid and semi-rigid vinyls are used in order to get good abrasion resistance and permanence.

Tests have shown the outstanding properties of the new material. Corrosion resistance of the laminate is superior to that of metal coated with phenolic or alkyd finishes. The special adhesive used gives adhesion in excess of 40 lb per in. of width on a lap-off. In outdoor industrial atmospheres, 2 years' exposure showed no breakdown. After 1000 hr in 100% relative humidity at 160 F, panels were in excellent condition, with no adhesion failure or blistering, and only slight color change and loss of gloss. Panels exposed to intermittent water spray

at ambient temperature for a year showed no deterioration. Oven aging at 150 F for 600 hr had no perceptible effect on adhesion or color. Temperatures even higher than 150 F are expected to be withstood. The vinyl does not become brittle at temperatures above —30 F. Resistance to ultra-violet light is influenced by the specific pigments used. Exposure for 500 hr to ultra-violet in a Twin-arc Weatherometer caused no perceptible chalking, although blue and white films discolored slightly and lost reflectance.

Abrasion resistance is far better than with conventional coatings for metals. Where the vinyl is cut or worn through, the pre-bonding metal treatments and the adhesive itself discourage undetermining rust. No stock failure due to pinholing was found when an 8 mil film was subjected to a 20,000 volt spark test.

The laminate can be fabricated on regular forming machines without damaging the coating. Deep drawing, 180 bends, 90 deg crimp bends and crimp rolls can be made by any sheet metal worker without special skill.

The material can be sheared, drilled or punched without chipping. Besides printing, embossing can be used on thick films. Patterns can even be stamped in the composite metal plastic sheet. The only real limitation in fabrication is that the laminate can not be soldered, brazed or welded without destroying the coating for a short distance on each side of the joint.

The exposed metal at the edges of stamped or cut parts—or where a joint has been effected—may, however, be protected. Where the edges are turned over, the possibility of rusting is often of little concern. In other places, pressure sensitive tape gives adequate cover against outdoor or chemical attack. Solvent coatings of high molecular weight polyvinyl chloride in special solvents can also be applied to small exposed areas.

Advantages

The metal-plastic laminate is superior to vinyl spray coated metal in several ways. In the first place, higher molecular weight resins can be rolled on in film form. These are more resistant to chemicals and heat. Then, too, a large amount of expensive solvents must be wasted with spray coats to build up successive layers for heavier coatings. A corresponding cost in the laminate to one thin spray coat is the price of the adhesive, which does not increase with the thickness of the vinyl film applied. Thus the new vinyl-metal composite gives better resistance at lower cost per mil thickness than vinyl spray-coated metal. Costs are about comparable with lacquered surfaces for very thin films and lower for thick films.

The advantages of the laminate over solid plastic for applications such as duct work lie in lower cost and superior structural strength. Solid plastic, especially where elevated temperatures are involved, must be supported to a greater extent than the new metal-backed material.

Competitive advantages are also indicated over stainless steel and galvanized sheet. The price will be about 1/3 that of comparable strength stainless steel. While the laminate will be more expensive than galvanized steel, the corrosion and abrasion resistance is much better. In one installation in a United States Rubber Co. plant, ducts carrying sulfuric and nitric acid fumes failed far short of one year when made of galvanized steel. The new laminate has now been in service for the full year and shows no sign of deterioration.

Applications

Although the laminate is not in full commercial production, it has been used experimentally by a wide cross section of manufacturing companies to produce a variety of items. These fabrications have illustrated the practicality of Marvinol-Metal Laminate being used in: chemical tanks; transportation units such as panel bodies; chemical conduit pipe and troughs; table tops, lawn and office furniture; ventilating ducts; air washing systems; back-up plates in switch boxes; pans for chemical driers; hospital equipment; industrial and office machine housings; instrument covers and panels; and drums, pails and cans for shipping chemicals.

Abrasion Resistance*

Coating	Film (Mils)	Total Rev.	Rev. Per Mil Coating
Marvinol-Metal	4.0	8,430	2,108
Marvinol-Metal	8.5	17,156	2,100
Phenolic	1.25	1,204	1,000
Urea-Alkyd	1.70	122	72
Vinyl Lacquer Coating	2.0 (Av.)	703–954	351–477

** Tests run on Taber Abrader with CS-10 wheel.*

Chemical Resistance

	Marvinol-Metal		Phenolic Coating		Alkyd Coating	
	Days	Result	Days	Result	Days	Result
10% Sulfuric Acid	17	OK	2	Failed	2	Failed
10% Nitric Acid	17	OK	2	Failed	2	Failed
10% Hydrochloric Acid	17	OK	2	Failed	2	Failed
10% Acetic Acid	17	OK	2	Failed	2	Failed
10% Lactic Acid	17	OK	17	Failed	2	Failed
10% Formaldehyde	11	Swelled	2	Failed	2	Failed
10% Caustic Potash	17	OK	3	Failed	2	Failed
Distilled Water	17	OK	17	Failed	2	Failed
Mineral Oil	17	OK	17	OK	17	OK
Ethanol	17	Sl. Shrink	17	OK	17	OK

Select the Right Method ↓

to Join Aluminum to Other Metals →

Legend

- ☒ Satisfactory Experience or Quite Easy
- X Limited Experience but Possible
- O Not Recommended
- □ No Experience

	Ferrous Alloys	Copper Alloys	Nickel Alloys	Magnesium Alloys	Silver Alloys	Precious Metals	Zinc Alloys	Lead Alloys	Tin Alloys	Com'l Electroplates or Hot Dip Coatings	Sintered Graphite Bronze	Titanium	Tungsten	Ceramics, Glass, etc	Plastics, Rubber, Wood, etc
Torch Welding	X	X	X	O							O				
Arc Welding	X	X	X	O									X		
Flash Welding	O	☒	O	O											
Resistance Welding	X	O		O											
Brazing	☒	X	X	O						X	O	X		X	
Transition Joints	X	X	X									X			
Hard Soldering	☒	☒	X	X	X		X			X	O	X		X	
Soft Soldering	☒	☒	☒	X	☒	☒	☒	☒	☒	☒	O	X		X	
Diffusion Welding	☒	☒	X		☒	X					☒				
Pressure Welding	☒	☒	X		X	X	☒	X	X						
Resin Bonding	☒	☒	X	☒	X	X	X	☒	X	X	X		X	☒	☒

Method picked depends on: (1) material involved, (2) design of part, (3) permissible joining temperatures, and (4) service requirements.

● ALUMINUM CAN BE JOINED to a large number of other metals by various methods. Arc, resistance and pressure welding; brazing; hard and soft soldering; resin bonding and certain specialized techniques are all applicable. These joining processes can be considered in four categories: 1) those which have given satisfactory results and are relatively simple to carry out, or both; 2) those with which there has been limited experience but which are possible to carry out; 3) those processes which are not recommended at the present stage of our knowledge, because of metallurgical, chemical or other interfering factors; and 4) such combinations of process and metal on which no experience is available at this time.

Torch Welding

Metallurgically, it would appear impracticable to join aluminum to ferrous or cuprous alloys by a welding technique, since it is known that brittle aluminum - iron and aluminum - copper compounds will form. This is certainly the case under ordinary circumstances. For this reason, direct torch welds of aluminum to copper or brass are not strong in the normal sense, but develop better strengths if the copper parts are first precoated with solders or silver brazing alloys, prior to welding with aluminum-base filler wire. These pretreatments result in better wettability and a shorter time at temperature; as a consequence, less brittle phases are formed.

Even better ductility in aluminum to copper torch welds, with aluminum-base filler wire, can be obtained by mixing the welding flux with a fairly large amount of a cadmium halide or cadmium metal powder and then welding in the normal manner. However, the joints cannot be considered ductile in the usual sense but this may be of little consequence

by MIKE A. MILLER, ASSISTANT CHIEF, Process Metallurgy Div., Aluminum Research Laboratories, Aluminum Co. of America

for specific applications, such as certain electrical joints. When these fluxes are used, precautions should be taken to prevent inhaling cadmium-bearing fumes.

In the case of ferrous and nickel-base metals, somewhat the same situation exists as with copper alloys, namely, welded joints are difficult to make and are brittle. Pretinning the steel with solder or pure zinc improves the ease of torch welding. In addition, the brittleness can be somewhat minimized by the welder by favoring the metal prone to produce the least brittle phase, i.e., the aluminum.

Welds of aluminum to magnesium are extremely brittle and are not recommended. Since a flux is used in torch welding, porous materials, such as certain sintered products, should not be torch welded to aluminum.

Arc Welding

Somewhat the same observations which have been made concerning torch welding apply to arc welding. One major difference between torch and arc welding is the shorter time at temperature in the case of the latter, and this, of course, decreases diffusion and minimizes brittle-phase formation. Ordinary arc-welding processes do not look encouraging. Satisfactory joints have been made between aluminum and aluminum-coated steel by using argon-shielded tungsten-arc welding in such a way that the arc favors the aluminum and permits wetting without excessive brittle phase formation. If the coated steel part is supplied too much heat, the aluminum coating is lost by diffusion and a joint cannot be effected.

For making electrical connections in small diameter wires, a special arc-welding technique has been used to join aluminum to copper. Inherently, alloying of copper and aluminum results in a brittle combination as pointed out in the preceding section and, as a consequence, the resulting welds must be well protected mechanically. A more ductile joint is obtained when the percentage of copper in the weld bead is kept as low as possible. This can be accomplished by using an aluminum sleeve or wire-wrap when joining this combination so as to provide an excess of aluminum in the weld bead.

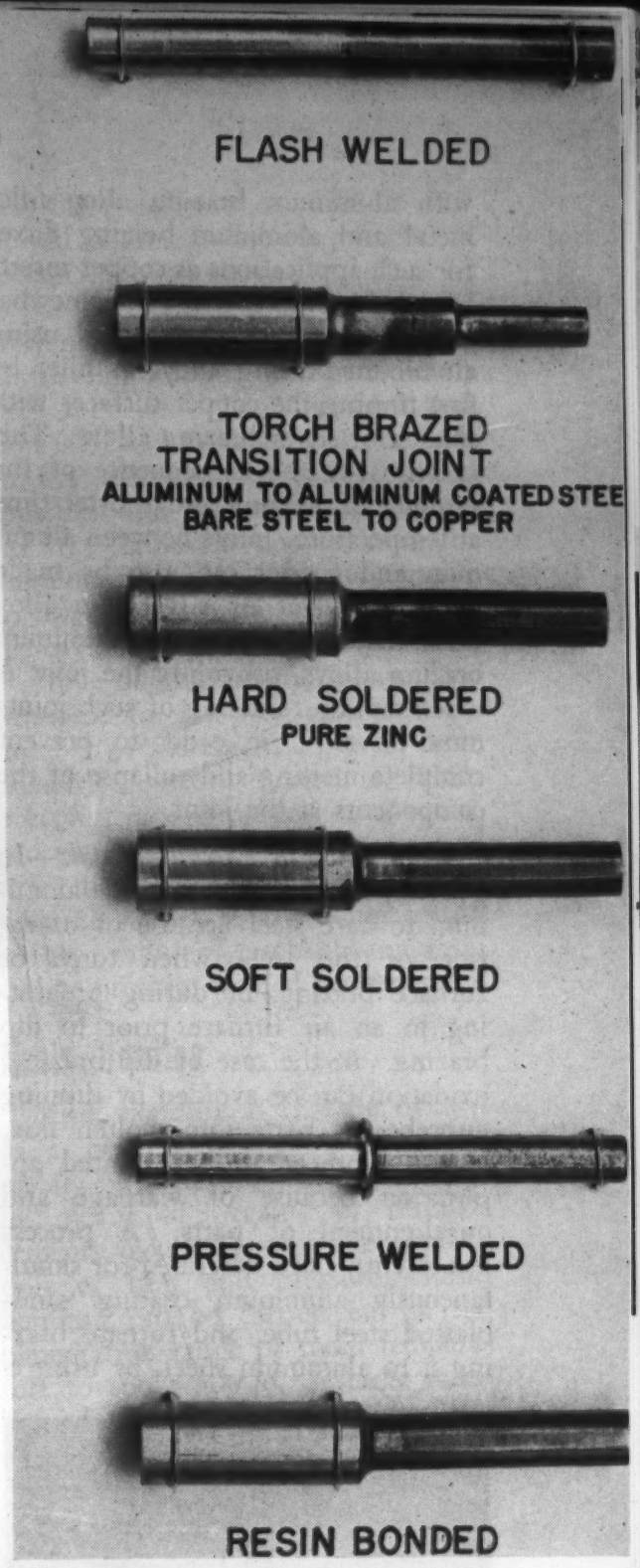
Using a special d.c. arc welding torch with a replaceable carbon electrode, aluminum can be readily welded in an air atmosphere to copper, brass, iron, steel, Nichrome, Chromel, Alumel, Constantan and tungsten.

Flash and Resistance Welding

Copper can be readily flash welded to aluminum and such joints in tubing have been in use for many years in building refrigerators. In a flash-welded joint, it is necessary to force out the low melting, brittle constituents during the upsetting portion of the cycle, in order to make the resulting joints ductile. Aluminum shapes other than tube, such as wires, round rods, extruded shapes and sheets of aluminum, have been flash welded to similar shapes of copper. Such joints have found use in the substitution of aluminum for copper coils on heavy, high-speed rotating electrical equipment, moving coils of electrical measuring instruments and transition joints in tubing between aluminum refrigerator evaporators or condensers and copper parts of compressors.

By careful adjustment of welding conditions, copper base alloys such as the brasses can be joined to aluminum by flash welding. However, experience has shown that, although copper and brass can be made to produce satisfactory joints, steel produces rather brittle joints by this procedure. Aluminum to steel joints can be made by using an intermediate copper section, which can be flash welded to aluminum at one end and to steel at the other.

Spot or seam welding aluminum and its alloys to a dissimilar metal or alloy is difficult and procedures involving bare ferrous metals have produced inconsistent results. Hess and Nippes have had some success with an intermediate metal plating layer to effect a satisfactory bond between aluminum and aircraft-type steels. They found that the most promising method was to electroplate 0.25 mil of silver on the steel parts and to spot or seam weld after this, employing suitably cleaned aluminum parts. Silver electroplates produced high-strength, ductile welds independent of welding current and electroplate thickness over a wider range. Other electroplates on steel were less satisfactory than silver in spot welding to aluminum. It is interesting to note that aluminum brazing sheet produced better spot welds to steel than did 3S alloy, probably because the brazing alloy coating melted at a lower temperature, thus permitting lower heat input.



Joints between aluminum and copper tubing can be made by the methods illustrated above.

Resistance welding of aluminum to copper or copper alloys is not practical because of the extreme brittleness of the joints.

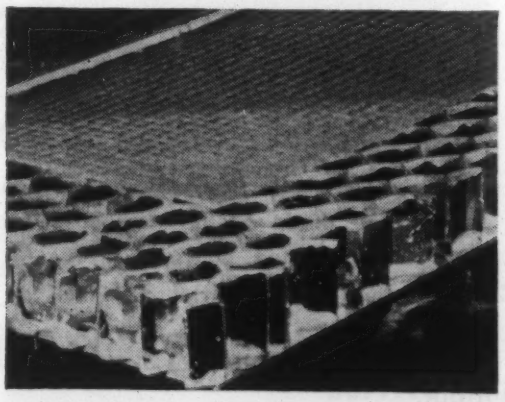
Brazing

Aluminum brazing techniques can be used for joining aluminum to other metals, particularly the ferrous alloys, providing the latter are given special surface pretreatments.

Aluminum to Copper—It is difficult to braze copper and its alloys to aluminum because of the low melting temperature of the aluminum-copper eutectic composition and its extreme brittleness. However, by rapidly heating and cooling, reasonably ductile joints have been obtained

with aluminum brazing alloy filler metal and aluminum brazing fluxes for such applications as copper inserts in aluminum castings. Somewhat better joints can be obtained using aluminum brazing alloys as filler by first tinning the copper surfaces with solders or silver brazing alloys. This is primarily the consequence of the rapidity of wetting and shorter time at temperature. Joints between aluminum and copper can also be made by using silver or silver-base alloy filler material instead of aluminum brazing alloys, providing the joint is made rapidly. Cooling of such joints must be rapid in order to prevent complete melting and collapse of the components at the joint.

Aluminum to Ferrous Metals—In general, it is difficult to braze aluminum to bare steel because of oxidation of the steel when torch or furnace brazing, or during preheating in an air furnace prior to dip brazing. In the case of dip brazing, oxidation can be avoided by dipping unpreheated parts into molten flux, but this procedure has limited application because of warpage and misalignment of parts. A process has recently been described for simultaneously aluminum coating sand-blasted steel tube, and furnace brazing it to aluminum sheet, by using a special procedure.



This aluminum honeycomb sandwich shows use of resin bonding. Top facing cut away to show adhesive bead.

Electroplated steels can be brazed to aluminum more readily than can bare steel. Iron, copper, nickel or zinc electroplates and zinc or aluminum hot-dip coatings have been used to promote wetting of the steel. Zinc electroplates have also been used to good advantage. For example, dip-brazed lap joints, made by slipping 1.30-in. dia zinc-plated mild steel tubes into 53S alloy tubes, using about an inch lap and aluminum brazing alloy wire, required a load of 30,000 lb to push the steel tube through the aluminum alloy tube.

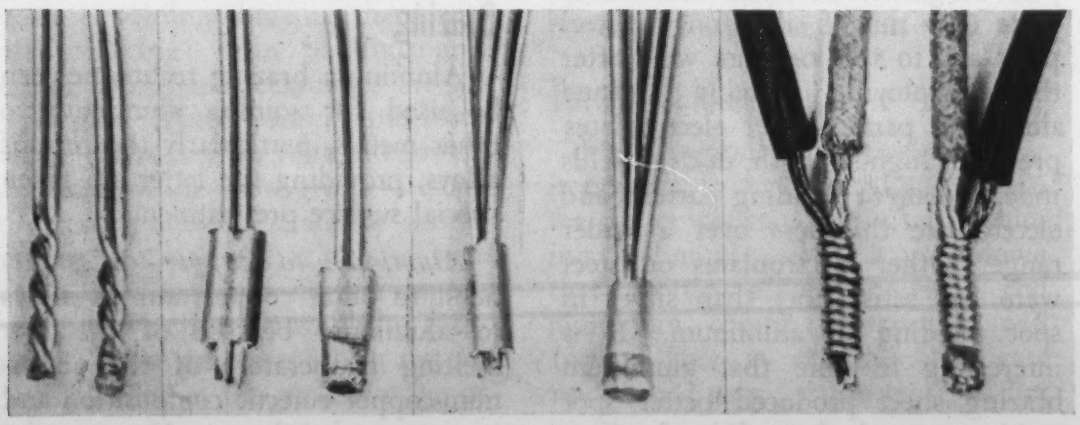
Probably the most satisfactory surface preparation for ferrous parts, prior to brazing them to aluminum, is to coat them with aluminum or an aluminum alloy. There are a number of products, processes and techniques that can be used for this purpose. It should be noted that in all cases somewhat brittle iron-aluminum compounds are formed at the interface. When a rapid method of brazing can be used, so as not to increase the thickness of the brittle compound layer, aluminum brazing is probably the most practical answer to the problem of durable aluminum to steel applications. The type of joint and the conditions of its use are, of course, to be considered in view of the difference in thermal expansion between aluminum and ferrous materials.

Aluminum-coated steels can be readily torch brazed to aluminum, using available aluminum brazing alloys and fluxes. The procedure is the same as would be used to braze aluminum to aluminum, except that it should be done more rapidly to minimize brittle phase formation.

When a rapid preheat can be used, dip brazing of aluminum-coated steel to aluminum can produce excellent joints. Tube to tube joints, with a nominal clearance of about 0.010 in. and laps varying from 0.50 to 2.50 in., have developed shear strengths of 10,000 to 15,000 psi.

Since a flux is used in the aluminum brazing process, it is important that all flux residues be removed after brazing. Where this is impossible, as in certain complex or specialized applications, a three-step procedure can sometimes be employed. For example, the steel parts can be hot-dipped in aluminum, either completely or locally, followed by brazing an aluminum section to the aluminum-coated steel. The subassembly should then be thoroughly cleaned to remove all flux residues, after which the aluminum section can be welded to the aluminum parts of the final assembly by argon-shielded tungsten-arc or consumable electrode methods.

Aluminum to Other Metals—Nickel, Inconel and monel have been experimentally brazed to aluminum and are no more difficult to braze, under proper conditions, than are ferrous parts. Titanium may be hot-dip coated with aluminum, after which it can be brazed to aluminum with aluminum brazing alloys. Magnesium alloys, of course, should not be brazed to aluminum because of the extremely brittle aluminum-magnesium phases that form during brazing.



Various types of wire joints before and after welding with a special d.c arc welding torch.

Transition Joints

In cases where for metallurgical or other reasons it is impractical to join aluminum to another metal directly, an intermediate or transition metal section can sometimes be used to advantage. The use of a copper transition section between aluminum and steel, assembled by flash welding, was mentioned earlier. Where flash welding of the copper and steel portions is not possible, as for example in field erection of assemblies, this joint could in some cases be made by silver alloy brazing.

For certain applications, a steel transition section can be used between aluminum and copper parts. In making such a joint, the steel section should be first dip coated with aluminum at one end, the coated end brazed, or in some cases welded, to the aluminum section by aluminum brazing or welding techniques and the bare end silver or copper alloy brazed to the copper section. Such joints are useful for assembly of parts in which the copper portion cannot be joined to aluminum by flash welding because of size, shape or position.

Soldering

Hard Soldering—Aluminum can be joined to a number of other metals with pure zinc or zinc-base alloys. Since zinc is a fillet-former it is generally desirable to design joints between aluminum and other metals with taper fits for tube, or line contacts for other parts.

Copper or brass parts need only be cleaned in any convenient manner. Heating may be in a furnace or by means of torch. Pure zinc, zinc-aluminum, zinc-copper and zinc-tin alloys may be used as filler; the last named has a poorer resistance to corrosion than the others but can be applied at lower temperatures.

In addition, nickel, magnesium, silver and zinc have been experimentally hard soldered to aluminum with zinc-base alloys.

Soft Soldering—Aluminum can be soft soldered, directly or indirectly, to practically all commercial metals and alloys. In the absence of fluxes to remove the oxide film from aluminum, rub-tinning or other mechanical means is required to remove the oxide film and effect and "tinned" surface. Many commercial soldering fluxes for aluminum are salt-type fluxes, generally based on zinc chloride or other heavy metal halides, together with smaller amounts of other chlorides and fluorides. Such chloride fluxes are very effective on aluminum but the residues are generally hygroscopic and can accelerate corrosion of aluminum, particularly when in contact with a dissimilar metal. It is very important, therefore, that all such flux residues be removed. This may be difficult to do for certain kinds of joints. In such cases it would be desirable to use a chloride-free soldering flux.

One such flux is an organic-base material in the form of a viscous liquid. This material contains no chlorides and is not corrosive to aluminum. Residues of this flux are virtually without effect as far as acceleration of corrosion is concerned. Stainless steels, Alnico magnet alloy, Kovar, cast iron, etc., are all readily solderable with the flux. The only metals found not to be readily solderable are magnesium and the so-called refractory metals — titanium, ziroconium, columbium, tantalum, molybdenum and tungsten. However, such metals can be soldered to aluminum after electroplating with a solderable metal, by tinning the surface with silver alloy solder or other special procedures. For example, titanium that has been hot-dip coated with aluminum can readily be soldered to aluminum with an aluminum solder and a chloride-free flux. Tin- or solder-coated aluminum wires can, of course, be soldered with rosin-cored lead-tin solders.

Diffusion Welding

Diffusion welding can be employed for the joining of aluminum to other metals, using silver electroplates on the parts. In carrying out the process, the silver-plated parts are simply pressed together at rather low pressures and at temperatures up to 600 F for a period of time. The recrystallization temperature of cold-worked silver is about 390 F, and it has been found that adherent welds cannot be made below this temperature even at pressures as high as 45,000 psi. In some cases only the aluminum surface needs to be electroplated with silver.

Rolling of component parts, naturally, is analogous in many respects to pressing, except that somewhat greater deformations might be required. Thus, silver-plated aluminum can be joined to silver-plated steel or copper by preheating the component parts to about 750 F and rolling them together with about a 50% reduction in area on the first pass. Basically, rolling parts together is no different than pressing the same components, the idea being to join aluminum to another metal. Rolled parts, in general, have a more limited shape factor than do pressed parts. This technique, however, can produce composite parts that either can be used in the as-fabricated form or can subsequently be joined to other metals.

Pressure Welding

Pressure welding is the formation of a solid-phase weld between metallic materials by the application of a deforming pressure at any temperature below the melting point of the components. In contrast to diffusion welding, pressure welding generally requires appreciable deformations to effect satisfactory bonds, the deformation generally decreasing with increasing temperature.

The deformation required for satisfactory pressure welding at room temperature varies with the metals being welded. Some optimum values are 20% deformation for scratch-brushed gold, 60% for aluminum and 80% for iron. It is apparent that controlled deformation must be employed in pressure welding dissimilar metals.

For hot-pressure butt welding of aluminum to copper, a modification of the simple butt joint has recently been suggested. The aluminum portion is heated to about 1125 F while in the die, and the parts pressed together with a hammer blow, forcing the unheated copper into the aluminum to give a slight "flash", corresponding to the contour of the die cavity.

Three different methods have been proposed for hot-pressure welding a number of aluminum alloys to steel, namely, a twisting procedure, a hot-pressing procedure and a shearing procedure. In addition to copper and steel, nickel, zinc and lead have been pressure welded to aluminum. With proper conditions, probably any metal can be pressure welded to aluminum.

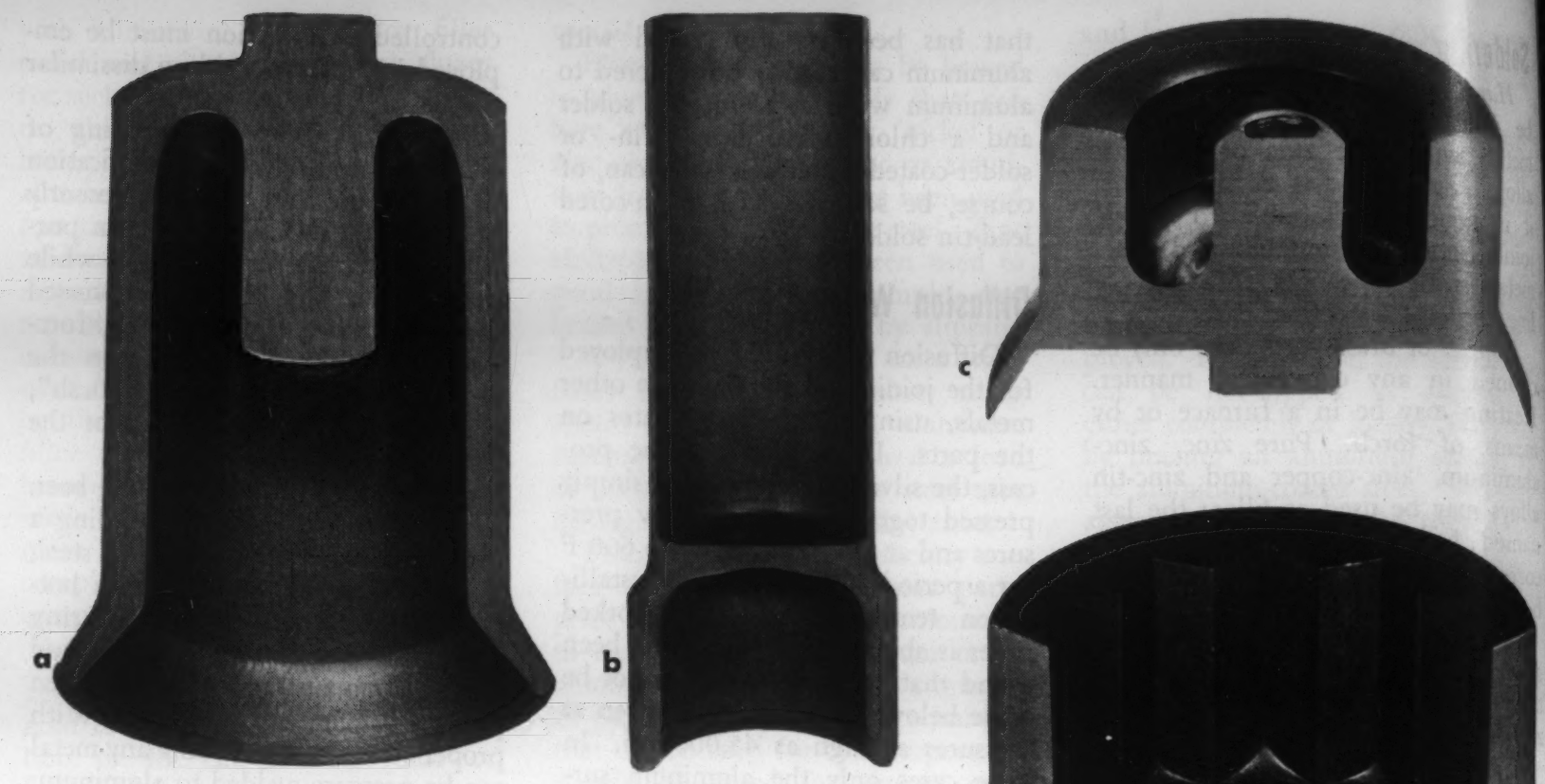
Resin Bonding

Resin bonding is broadly defined as a process of making metal to metal, or metal to nonmetal joints by means of organic or resinous cements, generally with the application of heat and pressure. Resin bonding can be carried out in the temperature range of room temperature to about 500 F. A large number of adhesives, both cold-setting and hot-setting, are commercially available.

Resin-bonded joints should be designed to take shear loads, the strength developed being dependent on the adhesive and the length and type of lap joint involved. These adhesives, being organic in nature, cannot be used for elevated temperature service.

Aluminum has been resin bonded to a great many types of metals and non-metals, but suitable adhesives must, of course, be chosen. Among the metals that have been bonded to aluminum are brass, galvanized iron, magnesium, stainless steel, copper, tin plate, lead, etc. Surface preparation, particularly of the aluminum, is very important. As would be expected, certain adhesives give higher strength joints on some metals than others. In fact, some adhesives give no wetting or adhesion on certain metals. Accordingly, in resin bonding dissimilar metals, care should be taken to use an adhesive that gives the optimum strength on both metals.

This article is based on a paper presented at the National Spring Meeting of the American Welding Society, June, 1953.



DIVERSIFIED FORMS of extruded steel are shown here. Shape a shows integral inside and outside stud complete as it comes from the press. Shape b contains an integral web which can be formed of any thickness or contour, and can be located at any point in the tube. The thin walled flanges on shape c are formed in combination with integral top and bottom inside studs and can be shaped in any thickness, length or angle. Shape d shows the lands or flutes which can be produced on inside or outside surfaces, at top or bottom, in any length and combination.

Intricate Steel Shapes

Accuracy and smoothness of finished forms and low scrap loss are big advantages.

● EVER SINCE WORLD WAR II, interest in the cold working of steel has grown with the increasing realization of its advantages and economies. The cold extrusion process is somewhat similar to cold drawing except that with the former, the metal is squeezed and kneaded rather than stretched into the desired shape. Recently the Mullins Manufacturing Corp., one of the companies that has been instrumental in furthering the development of this technique, demonstrated some of the intricate and highly finished shapes now attainable by the Koldflow extrusion process.

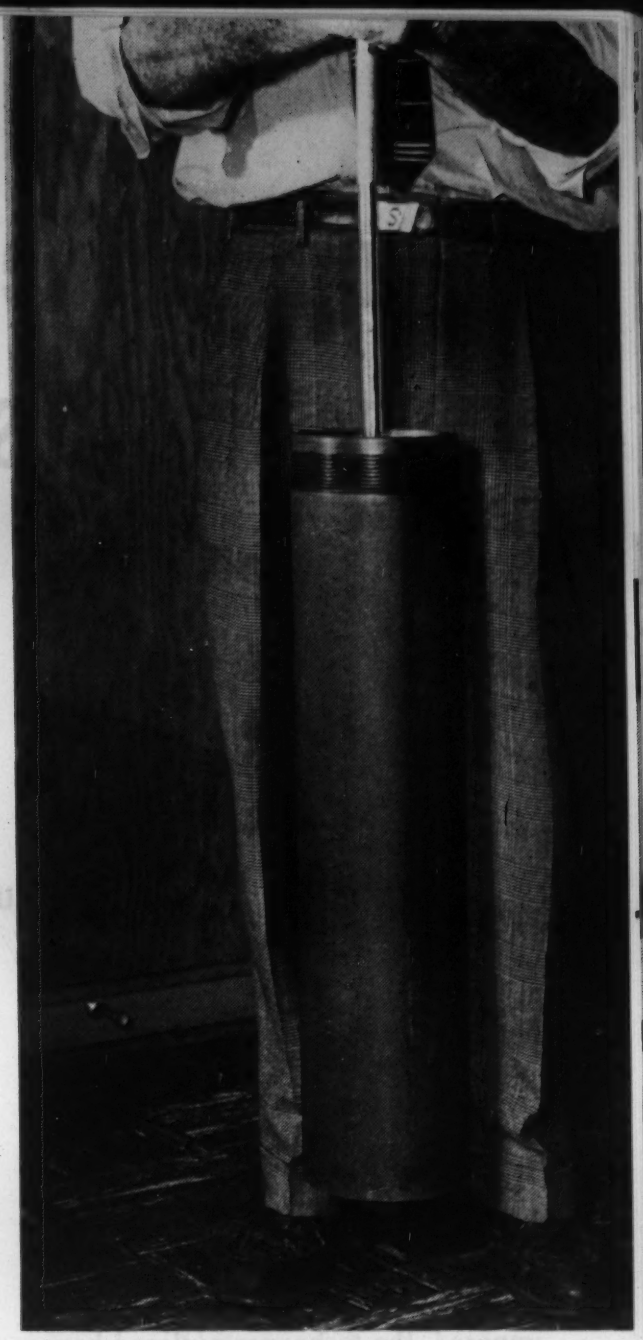
Cold extruded shapes are formed by forcing the metal, which is at room temperature, into dies by the steady application of pressure. The dies trap the metal to be worked, and eased by a lubricant bound to the metal by a phosphate coating, squeeze the metal through the die aperture until it conforms to the dimensions of the cavity.

One of the important advantages of this shaping process is the low scrap loss. For instance, in the cold extrusion of a 35-lb projectile for the Army Ordnance Dept., scrap loss was less than 1% due to the elimination of the highly wasteful, but previously required, machining processes. It was also announced that by extruding projectiles, improved concentricity resulting from the lack of exterior machining gave greater accuracy to the shell.

Since the kneading action of the cold extrusion process increases the strength of the metal without heat treating, low carbon, low manganese steels are used where previously a more expensive, high grade steel was necessary. It is further believed that the kneading irons out faults commonly found in the cheaper forms of raw stock.

In determining the work for which this process might be particularly well suited several general criteria may be used. First, the material to

HYDRAULIC PRESSES carrying dies that shape metal at room temperature at Mullins Corp.



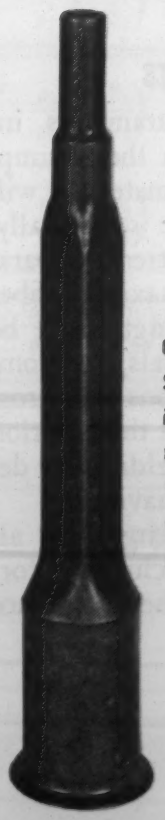
ACCURACY AND SMOOTHNESS possible with extrusions are illustrated by the inside surface of this accumulator pressure cylinder, meeting a tolerance of one half of one thousandth of an inch. The plug gage supports the weight of the cylinder when the air valve in the gage is closed.

Now Cold Extruded

by **MALCOLM W. RILEY**, Assistant Editor, Materials & Methods

be worked should be a ferrous material of low carbon content. If it is not to be subjected to critical temperatures, a yield strength of 75,000 psi upwards should be desired, and an elongation of 10% or more. In regard to the length of extrusions for which the process is practical, the Germans, who did a great deal of ground work on cold extrusion during the war, established a ratio of length to cross-sectional diameter of 24:1; though in backward extrusions it was limited to 4:1. In addition, the quantity of parts to be produced must be large enough to justify the high cost of dies and tools, and the manufacturer should be desirous of having press operations replace or reduce more conventional operations such as forging, casting and machining.

In general, the shapes for which this process has proved particularly adaptable have been of a cylindrical nature; however, with the later developments in the field, more intricate and diversified forms have become possible. The accompanying pictures show some of the variations in shape and size of cold extruded steel as developed by the Mullins Corp., and the highly smooth finish possible from this process.



COMBINATION OF SHAPES in one extrusion is shown in this piece, the top and bottom of which are round inside and out, while the center portion is square both inside and out.

Selecting Materials to Meet Mechanical Design Requirements

Here is a rational approach to the problem of selecting materials in mechanical design. Where the conditions and requirements of an application fall within the limits of this method, the working tables and formulas can help you determine the most economical material to use.

by LCDR J. R. HUNT, USN, Materials Development Div., Bureau of Ships, Navy Dept.

● MANY BASIC CHARACTERISTICS are important in the selection of a material for a particular mechanical application and one or more performance parameters are significant for any structural application. This article shows how certain characteristics of materials influence some performance parameters. Within the limits imposed, the technique outlined here can be used in arriving at a rational basis for selecting materials to meet specific mechanical requirements.

There are a large number of significant variables which are not considered in this discussion because most of them do not lend themselves to the simplified approach used. These include corrosion resistance, appearance, applicable fabricating practices, failure by fatigue and fracture.

The basic material characteristics considered are: 1) yield strength; 2) elastic modulus; 3) density; and 4) price.

Performance Parameters

The performance parameters included are all based on the assumption that each of the materials will serve the same purpose structurally. This means that for strength parameters the ratio of the maximum fiber stress to the yield strength will be the same for all materials, for comparable loading conditions and cross section; this implies that the criterion for failure is plastic yielding or departure from elastic behavior.

The use of yield strength for all loading conditions including torsional, is based upon the acceptance of the maximum shear stress criterion for yielding. This criterion precludes the necessity for a "shear yield strength" concept to describe yielding during shear or torsional loading. There are other criteria for failure, such as fracture and fracture by fatigue that are not considered because the approach is not applicable to more involved phenomena such as these. For stiffness parameters, the elastic deflections will be the same for all materials under identical loading conditions and comparable sections.

The parameters considered are:

1. (a) relative depth or diameter of section for equal strength
   (b) relative depth or diameter of section for equal stiffness
2. (a) relative volume for equal strength
   (b) relative volume for equal stiffness
3. (a) relative weight for equal strength
   (b) relative weight for equal stiffness
4. (a) relative cost for equal strength
   (b) relative cost for equal stiffness

Loading Conditions and Cross Sections

Types of loading and of cross sections considered are of necessity limited in both variety and complexity. The approach is such that the moment of inertia of the cross sections must vary in a simple, predictable manner with a single variable dimension for each cross section type used. This precludes the use of such common sections as channels, angles, I's, hollow rounds, etc. as far as the actual numerical results are concerned, but semi-quantitative conclusions can be drawn for such sections in terms of the results for the simplified sections used. The types of loading and cross sections considered are as follows:

1. Rectangular sections loaded as beams, width held constant, depth varied:
   strength proportional to depth^2
   stiffness proportional to depth^3
2. Solid cylinders loaded as beams, diameter varied:
   strength proportional to diameter^3
   stiffness proportional to diameter^4
3. Solid cylinders loaded in torsion, diameter varied:
   strength proportional to diameter^3
   stiffness proportional to diameter^4
4. Solid cylinders loaded in tension or compression, diameter varied:
   strength proportional to diameter^2
   stiffness proportional to diameter^2
5. Solid cylinders loaded as columns (slender—euler formula) — diameter varied — axial load carrying capacity proportional to diameter^4
6. Cylindrical pressure vessels or

pipe, internally loaded, (thin walled), inside diameter held constant, wall thickness varied: capacity to withstand pressure proportional to (wall thickness)

Alloys Considered

Six different base groups of alloys are considered with three separate alloys for each group (see table). The alloys selected within each group represent a relatively low strength, intermediate strength and high strength structural alloy for the group. The yield strength values are intended to include the generally useful lower and upper limits for each group. The alloys, with the exception of the high strength steel and magnesium alloy, are supplied in sheet form. Many of the alloys are also supplied in other wrought forms.

Numerical values for the basic characteristics of the alloys are shown in the table. The numerical values that quantitatively represent several characteristics of each alloy were selected in an endeavor to be as realistic as possible and at the same time develop a simplified, easy-to-use table for comparison purposes. Compromise is inherent in situations of this nature and the following refers to the assumptions used in arriving at actual values for each characteristic.

Yield Strengths—To reiterate, the three alloys within each group were selected to be approximately representative of the lower, intermediate and upper levels of yield strengths in use for structural purposes for each group. Minimum specification values are given where such exist, otherwise commonly accepted values for minimum yield strength are used. They are usually for 0.2% offset or its equivalent.

Elastic Moduli—Considerable controversial data have been published on elastic moduli, both Young's and shear, for the alloys considered. Therefore, it was necessary to select values that may appear to be somewhat arbitrary. In the interests of simplicity, a single modulus was chosen to represent the three alloys within each group, although minor differences exist in some cases among several alloys. It is believed that this simplification is justified in terms of the added usefulness of the comparison table.

Densities—For the reasons stated for elastic moduli, a single density was selected to represent the three alloys within each base group.

Prices—The comparison table is such that actual prices of the alloys are unimportant. The important consideration is that the relative prices appearing in the table be in the same relation as the prices of the alloys to the fabricator or consumer. For example, 1010 steel is listed at $0.05 per lb and 75ST6 aluminum at $0.50. If the actual prices to the consumer are $0.09 per lb for the steel and $0.90 for the aluminum, the cost parameter for these two alloys will be accurate, since both pairs of prices are in the ratio of 1 to 10. The pricing basis is for sheet material purchased in relatively large quantities with an absolute minimum of extras. Since the price structures for the several base groups are the results of independent, evolutionary growth, it is virtually impossible to present a schedule of prices that will be completely representative of the various alloys under a variety of conditions. Sheet prices are shown for products that are supplied in sheet form and are not necessary representative of solid cylindrical shapes, for which performance parameters are given, or of other wrought shapes.

Thus, the prices shown are merely guides. Where accurate cost parameters are desired for a specific application, corrections must be made in terms of actual unit prices of the alloys to the fabricator or consumer. The method for applying these corrections is illustrated later.

Table of Formulas for Performance Parameters

Loading and Cross Sections	Variable Dimension	Relative Variable Dimensions		Relative Volumes		Relative Weights		Relative Costs	
		Equal Strength Rds_2 RDs_2 Rts_2	Equal Stiffness $Rdst_2$ $RDst_2$	Equal Strength RVs_2	Equal Stiffness $RVst_2$	Equal Strength RWs_2	Equal Stiffness $RWst_2$	Equal Strength RCs_2	Equal Stiffness $RCst_2$
Rectangles in Bending	Depth (d)	$\left(\frac{YS_1}{YS_2}\right)^{1/2}$	$\left(\frac{E_1}{E_2}\right)^{1/3}$	$\left(\frac{YS_1}{YS_2}\right)^{1/2}$	$\left(\frac{E_1}{E_2}\right)^{1/3}$	$\left(\frac{YS_1}{YS_2}\right)^{1/2}\times\frac{\rho_2}{\rho_1}$	$\left(\frac{E_1}{E_2}\right)^{1/3}\times\frac{\rho_2}{\rho_1}$	$\left(\frac{YS_1}{YS_2}\right)^{1/2}\times\frac{\rho_2}{\rho_1}\times\frac{P_2}{P_1}$	$\left(\frac{E_1}{E_2}\right)^{1/3}\times\frac{\rho_2}{\rho_1}\times\frac{P_2}{P_1}$
Solid Cylinders in Bending	Diameter (D)	$\left(\frac{YS_1}{YS_2}\right)^{1/3}$	$\left(\frac{E_1}{E_2}\right)^{1/4}$	$\left(\frac{YS_1}{YS_2}\right)^{2/3}$	$\left(\frac{E_1}{E_2}\right)^{1/2}$	$\left(\frac{YS_1}{YS_2}\right)^{2/3}\times\frac{\rho_2}{\rho_1}$	$\left(\frac{E_1}{E_2}\right)^{1/2}\times\frac{\rho_2}{\rho_1}$	$\left(\frac{YS_1}{YS_2}\right)^{2/3}\times\frac{\rho_2}{\rho_1}\times\frac{P_2}{P_1}$	$\left(\frac{E_1}{E_2}\right)^{1/2}\times\frac{\rho_2}{\rho_1}\times\frac{P_2}{P_1}$
Solid Cylinders in Torsion	Diameter (D)	$\left(\frac{YS_1}{YS_2}\right)^{1/3}$	$\left(\frac{G_1}{G_2}\right)^{1/4}$	$\left(\frac{YS_1}{YS_2}\right)^{2/3}$	$\left(\frac{G_1}{G_2}\right)^{1/2}$	$\left(\frac{YS_1}{YS_2}\right)^{2/3}\times\frac{\rho_2}{\rho_1}$	$\left(\frac{G_1}{G_2}\right)^{1/2}\times\frac{\rho_2}{\rho_1}$	$\left(\frac{YS_1}{YS_2}\right)^{2/3}\times\frac{\rho_2}{\rho_1}\times\frac{P_2}{P_1}$	$\left(\frac{G_1}{G_2}\right)^{1/2}\times\frac{\rho_2}{\rho_1}\times\frac{P_2}{P_1}$
Solid Cylinders in Tension	Diameter (D)	$\left(\frac{YS_1}{YS_2}\right)^{1/2}$	$\left(\frac{E_1}{E_2}\right)^{1/2}$	$\left(\frac{YS_1}{YS_2}\right)$	$\left(\frac{E_1}{E_2}\right)$	$\left(\frac{YS_1}{YS_2}\right)\times\frac{\rho_2}{\rho_1}$	$\left(\frac{E_1}{E_2}\right)\times\frac{\rho_2}{\rho_1}$	$\left(\frac{YS_1}{YS_2}\right)\times\frac{\rho_2}{\rho_1}\times\frac{P_2}{P_1}$	$\left(\frac{G_1}{G_2}\right)\times\frac{\rho_2}{\rho_1}\times\frac{P_2}{P_1}$
Solid Cylinders as Columns	Diameter (D)		$\left(\frac{E_1}{E_2}\right)^{1/4}$		$\left(\frac{E_1}{E_2}\right)^{1/2}$		$\left(\frac{E_1}{E_2}\right)^{1/2}\times\frac{\rho_2}{\rho_1}$		$\left(\frac{E_1}{E_2}\right)^{1/2}\times\frac{\rho_2}{\rho_1}\times\frac{P_2}{P_1}$
Cylindrical Pressure Vessels	Thickness (t)	$\left(\frac{YS_1}{YS_2}\right)$		$\left(\frac{YS_1}{YS_2}\right)$		$\left(\frac{YS_1}{YS_2}\right)\times\frac{\rho_2}{\rho_1}$		$\left(\frac{YS_1}{YS_2}\right)\times\frac{\rho_2}{\rho_1}\times\frac{P_2}{P_1}$	

Some Limitations of the Performance Parameters

The cost parameters indicate relative material costs only and do not reflect the very significant differences that exist in fabricating costs for various materials. As fabricating costs often exceed material costs, it is very important that this be given consideration, because the true criterion for efficient design is the total cost of the finished product.

Another factor that must be considered is joint efficiencies. These differ significantly for various fastening and joining methods. Thus it is often impossible to utilize the full strength of the basic material because the weakest part of the assembly may be in the connections. This is particularly true for materials that do not lend themselves to moderate, low cost, high efficiency joining techniques such as welding.

How to Use the Alloy Comparison Table

The numerical values for perform-

Alloy Comparison Table

Alloy	Condition	Yield Strength (YS) Psi	Youngs Mod. (E) Psi x 10^6	Shear Mod. (G) Psi x 10^6	Density (ρ) Lb/In.^{3}	Price (P) $/Lb.	Rectangles in Bending								Solid Cylinders in Bending							
							Dimension		Volume		Weight		Cost		Dimension		Volume		Weight		Cost	
							Str. RD_s	Stiff. RD_{st}	Str. RV_s	Stiff. RV_{st}	Str. RW_s	Stiff. RW_{st}	Str. RC_s	Stiff. RC_{st}	Str. RD_s	Stiff. RD_{st}	Str. RV_s	Stiff. RV_{st}	Str. RW_s	Stiff. RW_{st}	Str. RC_s	Stiff. RC_{st}
STEELS																						
1010	Hot Rolled	25,000	30.0	12.0	.282	0.05	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
950	Hot Rolled	50,000	30.0	12.0	.282	0.08	7.1	10.0	7.1	10.0	7.1	10.0	11.4	16.0	7.9	10.0	6.2	10.0	6.2	10.0	9.9	16.0
4140	Q & T (35 Rc)	140,000	30.0	12.0	.282	0.10	4.2	10.0	4.2	10.0	4.2	10.0	8.4	20.0	5.6	10.0	3.1	10.0	3.1	10.0	6.2	20.0
ALUMINUM BASE																						
3SH14	Cold Worked	16,000	10.0	3.9	.099	0.37	12.5	14.4	12.5	14.4	4.4	5.1	32.5	37.7	11.6	13.2	13.4	17.4	4.7	6.1	34.8	45.2
61ST6	Heat Treated	35,000	10.0	3.9	.099	0.45	8.5	14.4	8.5	14.4	3.0	5.1	27.0	46.0	8.9	13.2	7.9	17.4	2.8	6.1	25.2	54.9
75ST6	Heat Treated	66,000	10.0	3.9	.099	0.50	6.2	14.4	6.2	14.4	2.2	5.1	22.0	51.0	7.2	13.2	5.2	17.4	1.8	6.1	18.0	61.2
MAGNESIUM BASE																						
AZ31X	Annealed	18,000	6.5	2.4	.064	0.75	11.8	16.7	11.8	16.7	2.7	3.8	40.5	57.0	11.2	14.7	12.5	21.6	2.8	4.9	42.0	73.5
M1	Cold Worked	22,000	6.5	2.4	.064	0.86	10.7	16.7	10.7	16.7	2.4	3.8	41.2	65.3	10.4	14.7	10.8	21.6	2.5	4.9	43.0	84.4
AZ80X	Heat Treated	30,000	6.5	2.4	.064	1.35	9.1	16.7	9.1	16.7	2.1	3.8	56.7	103	9.4	14.7	8.8	21.6	2.0	4.9	54.0	132
COPPER BASE																						
Yellow Brass	½ Hard	25,000	15.0	6.5	.305	0.41	10.0	12.6	10.0	12.6	10.8	13.6	88.5	113	10.0	11.9	10.0	14.1	10.8	15.2	88.5	124
Naval Brass	½ Hard	35,000	15.0	6.5	.305	0.44	8.4	12.6	8.4	12.6	9.1	13.6	80.1	120	8.9	11.9	7.9	14.1	8.5	15.2	74.8	134
Mn Bronze	½ Hard	60,000	15.0	6.5	.305	0.48	6.5	12.6	6.5	12.6	7.0	13.6	67.2	130	7.5	11.9	5.6	14.1	6.1	15.2	58.5	146
NICKEL BASE																						
Monel	Annealed	25,000	26.0	9.5	.319	0.70	10.0	10.5	10.0	10.5	11.3	11.9	158	167	10.0	10.4	10.0	10.8	11.3	12.2	158	171
Monel	Cold Worked	55,000	26.0	9.5	.319	0.73	6.7	10.5	6.7	10.5	7.6	11.9	111	174	7.7	10.4	5.9	10.8	6.7	12.2	97.8	178
K-Monel	Heat Treated	100,000	26.0	9.5	.319	1.37	5.0	10.5	5.0	10.5	5.7	11.9	156	326	6.3	10.4	4.0	10.8	4.5	12.2	123	334
TITANIUM BASE																						
TI-75A	Annealed	68,000	16.0	6.0	.166	15.00	6.1	12.3	6.1	12.3	3.6	7.2	1080	2160	7.2	11.7	5.2	13.6	3.1	8.0	930	2400
TI-100A	Annealed	100,000	16.0	6.0	.166	15.00	5.0	12.3	5.0	12.3	2.9	7.2	870	2160	6.3	11.7	4.0	13.6	2.3	8.0	690	2400
TI-150A	Annealed	120,000	16.0	6.0	.166	15.00	4.6	12.3	4.6	12.3	2.7	7.2	810	2160	5.9	11.7	3.5	13.6	2.1	8.0	630	2400

ance parameters that are shown in the alloy comparison table were obtained by substituting values for basic alloy characteristics into the appropriate parameter formulae. The values are strictly relative in nature and it is very important that the correct basis for comparisons be clearly understood. *Quantities should be compared only with other quantities that are shown in the same column.* Parameters for the low strength steel (AISI 1010) have a value of 10.0 and that this value heads each column of parameters. It is obvious that no comparisons can be made between columns. Any value within a column may be compared with any other value within the same column.

To use the table, it is first necessary to select the type of loading and cross section representative of the application under consideration. This is obviously not always possible, because of the limited number of conditions described herein. The next step is to decide whether strength or stiffness is the dominant design criterion. Finally, decide whether to

Alloy Comparison Table—Continued

Solid Cylinders in Torsion								Solid Cylinders in Tension								Solid Cylinders as Slender Columns				Cylindrical Pressure Vessels				Alloy
ension	Volume		Weight		Cost			Dimension		Volume		Weight		Cost		Dim.	Vol.	Wgt.	Cost	Dim.	Vol.	Wgt.	Cost	
Stiff.	Str.	Stiff.	Str.	Stiff.	Str.	Stiff.		Str.	Stiff.	Str.	Stiff.	Str.	Stiff.	Str.	Stiff.	Stiff.	Stiff.	Stiff.	Stiff.	Str.	Str.	Str.	Str.	
RD_{st}	RV_s	RV_{st}	RW_s	RW_{st}	RC_s	RC_{st}		RD_s	RD_{st}	RV_s	RV_{st}	RW_s	RW_{st}	RC_s	RC_{st}	RD_{st}	RV_{st}	RW_{st}	RC_{st}	RT_s	RV_s	RW_s	RC_s	
																								STEELS
10.0	10.0	10.0	10.0	10.0	10.0	10.0		10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	1010
10.0	6.2	10.0	6.2	10.0	9.9	16.0		7.1	10.0	5.0	10.0	5.0	10.0	8.0	16.0	10.0	10.0	10.0	16.0	5.0	5.0	5.0	8.0	950
10.0	3.1	10.0	3.1	10.0	6.2	20.0		4.2	10.0	1.8	10.0	1.8	10.0	3.6	20.0	10.0	10.0	10.0	20.0	1.8	1.8	1.8	3.6	4140
																								ALUMINUM BASE
13.3	13.4	17.7	4.7	6.2	34.8	45.8		12.5	17.3	15.6	30.0	5.5	10.5	40.7	77.8	13.2	17.4	6.1	45.1	15.6	15.6	5.5	40.7	3SH14
13.3	7.9	17.7	2.8	6.2	25.2	55.9		8.5	17.3	7.1	30.0	2.5	10.5	22.5	94.5	13.2	17.4	6.1	54.9	7.1	7.1	2.5	22.5	61ST6
13.3	5.2	17.7	1.8	6.2	18.0	62.0		6.2	17.3	3.8	30.0	1.3	10.5	13.0	105	13.2	17.4	6.1	61.0	3.8	3.8	1.3	13.0	75ST6
																								MAGNESIUM BASE
14.9	12.5	22.2	2.8	5.0	42.0	75.0		11.8	21.5	13.9	46.2	3.2	10.5	48.0	157	14.7	21.6	4.9	73.5	13.9	13.9	3.2	48.0	AZ31X
14.9	10.8	22.2	2.5	5.0	43.0	86.0		10.7	21.5	11.3	46.2	2.6	10.5	44.7	181	14.7	21.6	4.9	84.3	11.3	11.3	2.6	44.7	M1
14.9	8.8	22.2	2.0	5.0	54.0	135		9.1	21.5	8.3	46.2	1.9	10.5	51.3	284	14.7	21.6	4.9	132	8.3	8.3	1.9	51.3	AZ80X
																								COPPER BASE
11.6	10.0	13.4	10.8	14.5	88.5	119		10.0	14.1	10.0	20.0	10.8	21.6	88.5	177	11.9	14.1	15.2	124	10.0	10.0	10.8	88.5	Yellow Brass
11.6	7.9	13.4	8.5	14.5	74.8	128		8.4	14.1	7.1	20.0	7.7	21.6	67.7	190	11.9	14.1	15.2	134	7.1	7.1	7.7	67.7	Naval Brass
11.6	5.6	13.4	6.1	14.5	58.5	139		6.5	14.1	4.2	20.0	4.5	21.6	43.2	208	11.9	14.1	15.2	146	4.2	4.2	4.5	43.2	Mn Bronze
																								NICKEL BASE
10.6	10.0	11.2	11.3	12.7	158	178		10.0	10.7	10.0	11.5	11.3	13.0	158	182	10.4	10.8	12.2	171	10.0	10.0	11.3	158	Monel
10.6	5.9	11.2	6.7	12.7	97.7	185		6.7	10.7	4.5	11.5	5.1	13.0	74.5	190	10.4	10.8	12.2	178	4.5	4.5	5.1	74.5	Monel
10.6	4.0	11.2	4.5	12.7	123	348		5.0	10.7	2.5	11.5	2.8	13.0	76.6	356	10.4	10.8	12.2	334	2.5	2.5	2.8	76.6	K-Monel
																								TITANIUM BASE
11.9	5.2	14.2	3.1	8.4	930	2520		6.1	13.7	3.7	18.7	2.2	11.0	660	3300	11.7	13.6	8.0	4080	3.7	3.7	2.2	660	TI-75A
11.9	4.0	14.2	2.3	8.4	690	2520		5.0	13.7	2.5	18.7	1.5	11.0	450	3300	11.7	13.6	8.0	4080	2.5	2.5	1.5	450	TI-100A
11.9	3.5	14.2	2.1	8.4	630	2520		4.6	13.7	2.1	18.7	1.2	11.0	360	3300	11.7	13.6	8.0	4080	2.1	2.1	1.2	360	TI-150A

Material	Assigned Subscript	Yield Strength Psi	Elastic Modulus Psi	Density lb/sq in.	Price $/lb
Stainless Steel (X)	1	30,000	30×10^6	0.290	0.52
Aluminum (Y)	2	35,000	10×10^6	0.099	0.68

compare the alloys on the basis of relative variable dimensions, relative volumes, relative weights or relative costs.

Example:—Assume that a rectangular section loaded in bending is applicable, strength is the critical factor and that relative costs are desired. Enter the column headed RC_s (relative cost for the same strength) for rectangular beam loading and read:

1010	Steel	10.0
61ST6	Aluminum	27.0
AZ80X	Magnesium Base	56.7

This means that, within the limitations stated, the relative costs can be expected to be as indicated if the cross sectional dimensions are such that each material is stressed to the same proportion of its yield strength. If this proportion happened to be 0.5 (factor of safety of 2.0 based on yield strength) the alloys would be stressed as follows:

1010	Steel	12,500 psi
3SH14	Aluminum Base	17,500 psi
AZ31X	Magnesium Base	15,000 psi

Example:—Assume that a solid cylindrical section loaded in torsion is applicable, that elastic deflection is the critical factor and that relative weights are desired. Enter the column headed RWst (relative weight for the same stiffness) for solid cylinders in torsion and read:

3SH14	Aluminum Base	6.2
AZ31X	Magnesium Base	5.0
Yellow Brass		14.5

This means that, within the limitations discussed, the relative weights can be expected to be as indicated if the cross sectional dimensions are such that the torsional deflections are the same for each alloy. The relative diameters necessary to result in this condition can be obtained from the column headed RDst (relative diameter for the same stiffness).

How to Use the Parameter Formulas

The performance parameter formulas are applicable to any materials, metallic or non-metallic, and in any form such as castings, extrusions, etc. Thus, within the limitations of the loading conditions and cross sections shown, the formulas may be applied to problems that do not lend themselves to the alloys or values for basic material characteristics that are used in the comparison table. For example, suppose a fabricator is faced with the following problem: The design includes framing members that will be rectangular in section and subjected to beam loading. Strength is the primary design criterion and costs based on equal strength are desired. Product appearance, applicable fabricating practices and the availability of materials result in two materials being given serious consideration, with basic material characteristics shown in accompanying table.

Using the appropriate formula:

RC_s = (relative cost for equal strength)

$$\left(\frac{YS_1}{YS_2}\right)^{1/2} \times \frac{\rho_2}{\rho_1} \times \frac{P_2}{P_1}$$

$$RCs = \left(\frac{30{,}000}{35{,}000}\right)^{1/2} \times \frac{0.099}{0.290} \times \frac{0.68}{0.52}$$

$$RC_s = 0.926 \times 0.341 \times 1.31 = 0.414$$

Thus, the material cost incident to the use of Aluminum "Y" would be 0.414 times the material cost incident to the use of Stainless Steel "X". (Note: the sign convention is such that material with subscript 2 is always being compared with material with subscript 1). The relative dimensions, volumes and weights for the two materials may also be obtained by substituting in the appropriate formulas.

This paper represents only the personal views of the author and in no way reflects the official attitude of the U. S. Navy.

Derivations of Formulas

Rectangles Loaded in Bending

$$ST = \frac{My}{I} = \frac{M\left(\frac{d}{2}\right)}{\left(\frac{bd^3}{12}\right)} = \frac{6M}{bd^2}$$

$$\Delta = \frac{L\,l^3}{48EI} = \frac{L\,l^3}{48\,E\left(\frac{bd^3}{12}\right)}$$

Assume M, L, b and l are constant.

For equal strength—i.e., both materials stressed to the same proportion of their respective yield strengths:

$$\frac{ds_2}{ds_1} = Rds_2 = \left(\frac{YS_1}{YS_2}\right)^{1/2}$$

$$\frac{Vs_2}{Vs_1} = RVs_2 = \frac{ds_2}{ds_1}$$

$$\frac{Ws_2}{Ws_1} = RWs_2 = \frac{Vs_2}{Vs_1} \times \frac{\rho_2}{\rho_1}$$

$$\frac{Cs_2}{Cs_1} = RCs_2 = \frac{Ws_2}{Ws_1} \times \frac{P_2}{P_1}$$

For equal stiffness—i.e., beams of both materials have equal elastic deflections:

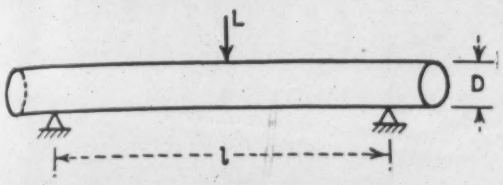
$$\frac{dst_2}{dst_1} = Rdst_2 = \left(\frac{E_1}{E_2}\right)^{1/3}$$

$$\frac{Vst_2}{Vst_1} = RVst_2 = \frac{dst_2}{dst_1}$$

NOTE: Specific types of loading and supporting are shown for these cases and they apply to the classical expressions for stress and deflection that accompany each example. It should be noted, however, that the formulas derived for the performance parameters are not restricted to the types of loading and supporting used. For instance, the parameters for cylindrical beams also apply to cylindrical cantilever beams with uniform loads, concentrated loads, etc. The same applies to column end conditions. This is due to the fact that the powers to which the dimensional variables (such as d or D) are raised in the stress and deflection expressions are independent of the type of loading or supporting.

NOTE: In this and ensuing derivations $\frac{Ws_2}{Ws_1}$, $\frac{Cs_2}{Cs_1}$, $\frac{Wst_2}{Wst_1}$ and $\frac{Cst_2}{Cst_1}$ are not included as they are obtained by modifying the $\frac{Vs_2}{Vs_1}$ and $\frac{Vst_2}{Vst_1}$ ratios by $\frac{\rho_2}{\rho_1}$ and $\frac{P_2}{P_1}$ as in the preceding derivation.

Solid Cylinders in Bending



$$St = \frac{My}{I} = \frac{M\left(\frac{D}{2}\right)}{\left(\frac{\pi D^4}{64}\right)} = \frac{32M}{\pi D^3}$$

$$\Delta = \frac{L\,l^3}{48\,EI} = \frac{L\,l^3}{48\,E\left(\frac{\pi D^4}{64}\right)}$$

Assume M, L and l are constant
For equal strength:

$$\frac{Dst_2}{Dst_1} = RDst_2 = \left(\frac{YS_1}{YS_2}\right)^{1/3}$$

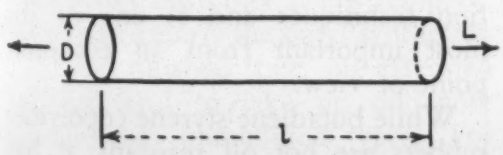
$$\frac{Vs_2}{Vs_1} = RVs_2 = \left(\frac{Ds_2}{Ds_1}\right)^2 = \left(\frac{YS_1}{YS_2}\right)^{2/3}$$

For equal stiffness:

$$\frac{Dst_2}{Dst_1} = RDst_2 = \left(\frac{E_1}{E_2}\right)^{1/4}$$

$$\frac{Vst_2}{Vst_1} = RVst_2 = \left(\frac{Dst_2}{Dst_1}\right)^2 = \left(\frac{E_1}{E_2}\right)^{1/2}$$

Solid Cylinders in Tension or Compression



$$St = \frac{L}{A} = \frac{L}{\left(\frac{\pi D^2}{4}\right)}$$

$$\Delta = \frac{L\,l}{E\,A} = \frac{L\,l}{E\left(\frac{\pi D^2}{4}\right)}$$

Assume L and l are constant
For equal strength:

$$\frac{Ds_2}{Ds_1} = RDs_2 = \left(\frac{YS_1}{YS_2}\right)^{1/2}$$

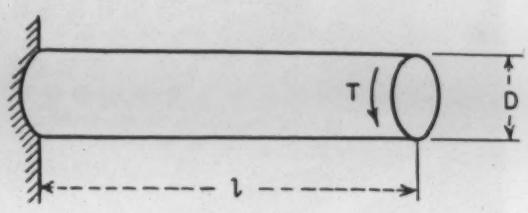
$$\frac{Vs_2}{Vs_1} = RVs_2 = \left(\frac{Ds_2}{Ds_1}\right)^2 = \left(\frac{YS_1}{YS_2}\right)$$

For equal stiffness:

$$\frac{Dst_2}{Dst_1} = RDst_2 = \left(\frac{E_1}{E_2}\right)^{1/2}$$

$$\frac{Vst_2}{Vst_1} = RVst_2 = \left(\frac{Dst_2}{Dst_1}\right)^2 = \left(\frac{E_1}{E_2}\right)^{1/2}$$

Solid Cylinders in Torsion



$$Ss = \frac{T\,y}{J} = \frac{T\left(\frac{D}{2}\right)}{\left(\frac{\pi D^4}{32}\right)} = \frac{16T}{\pi D^3}$$

$$\omega = \frac{T\,l}{G\,J} = \frac{T\,l}{G\left(\frac{\pi D^4}{32}\right)} = \frac{32\,T\,l}{\pi\,G\,D^4}$$

Assume T and l are constant
For equal strength:

$$\frac{Ds_2}{Ds_1} = RDs_2 = \left(\frac{YS_1}{YS_2}\right)^{1/3}$$

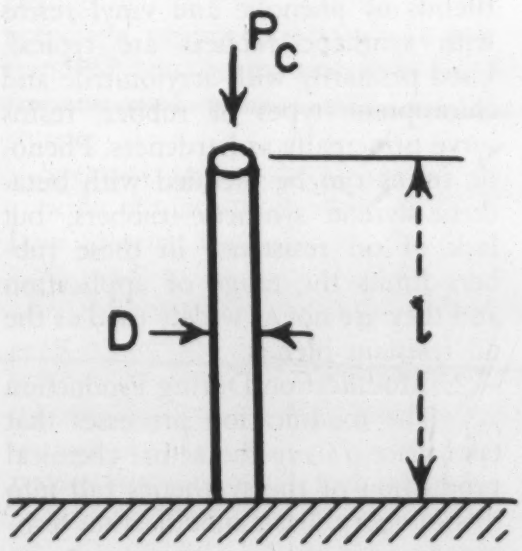
$$\frac{Vs_2}{Vs_1} = RVs_2 = \left(\frac{Ds_2}{Ds_1}\right)^2 = \left(\frac{YS_1}{YS_2}\right)^{2/3}$$

For equal stiffness:

$$\frac{Dst_2}{Dst_1} = RDst_2 = \left(\frac{G_1}{G_2}\right)^{1/4}$$

$$\frac{Vst_2}{Vst_1} = RVst_2 = \left(\frac{Dst_2}{Dst_1}\right)^2 = \left(\frac{G_1}{G_2}\right)^{1/2}$$

Solid Cylinders as Slender Columns



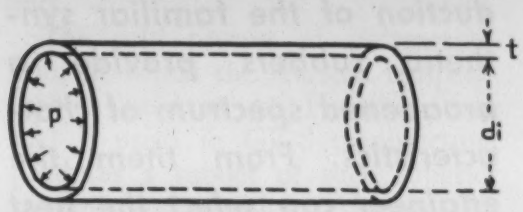
$$Pc = \frac{\pi^2\,E\,I}{l^2} = \frac{\pi^2\,E\left(\frac{\pi D^4}{64}\right)}{l^2}$$

Assume l is constant
For equal load carrying capacity:

$$\frac{Dst_2}{Dst_1} = RDst_2 = \left(\frac{E_1}{E_2}\right)^{1/4}$$

$$\frac{Vst_2}{Vst_1} = RVst_2 = \left(\frac{Dst_2}{Dst_1}\right)^2 = \left(\frac{E_1}{E_2}\right)^{1/2}$$

Cylindrical Pressure Vessels (Thin Walled)



$$St = \frac{\rho\,di}{2\,t}$$

Assume di is constant
For equal pressure ratings:

$$\frac{ts_2}{ts_1} = Rts_2 = \left(\frac{YS_1}{YS_2}\right)$$

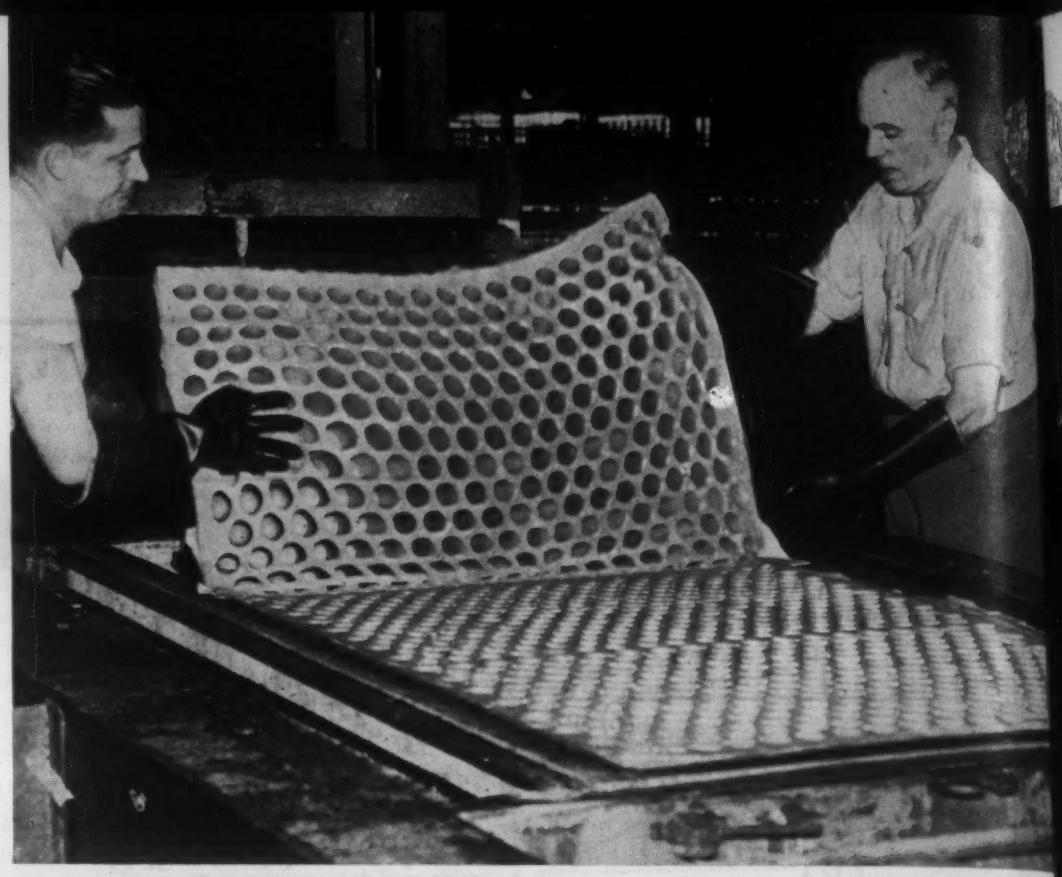
$$\frac{Vs_2}{Vs_1} = RVs_2 = \frac{ts_2}{ts_1} = \left(\frac{YS_1}{YS_2}\right)$$

Definitions

The following definition of terms apply to all derivations and discussions:

- YS —Yield strength, psi
- E —Young's modulus, psi
- G —Shear modulus, psi
- ρ —Density—lb/in.^{3}
- P —Price—$/lb
- b —Width of rectangular beam—in.
- d —Depth of rectangular beam—in.
- di —Internal diameter of cylindrical pressure vessel—in.
- D —Diameter of solid cylinder—in.
- t —Thickness of cylindrical pressure vessel—in.
- l —Length of beam or column—in.
- M —Bending moment—lb. in.
- T —Torsional moment—lb. in.
- L —Load on beam—lb.
- p —Internal pressure (pressure vessels)—psi
- A —Area of section—in.^{2}
- I —Moment of inertia of section—in.^{4}
- y —Distance from neutral axis to extreme fibre—in.
- γ —Radius of gyration of section—in.
- J —Polar moment of inertia—in.^{4}
- Pc —Safe load for slender columns—euler—lb.
- ds —Depth of rectangular beam for equal strength—in.
- dst —Depth of rectangular beam for equal stiffness—in.
- Ds —Diameter of solid cylinders for equal strength—in.
- Dst —Diameter of solid cylinders for equal stiffness—in.
- Ts —Thickness of cylindrical pressure vessels for equal strength—in.
- Vs —Volume for equal strength—in.^{3}
- Vst —Volume for equal stiffness—in.^{3}
- Ws —Weight for equal strength—lb
- Wst —Weight for equal stiffness—lb
- Cs —Cost for equal strength—$
- Cst —Cost for equal stiffness—$
- R —Prefix denoting a relative value
- 1, 2 —Subscripts denoting specific alloys
- St —Maximum unit tensile or compressive stress—psi
- Ss —Unit shear stress in outer fibres—psi
- Δ —Lateral bending deflection—in.
- ω —Torsional bending deflection—radians

Modifications during production of the familiar synthetic rubbers provide a broadened spectrum of characteristics. From them the engineer can select the best combination of properties to meet the economical and physical requirements of his products.



Soft, flexible, all-butadiene rubber is odorless, can be foamed for use in upholstery. At the opposite end of the scale from high styrene GR-S, low styrene rubber is soft, has good low temperature flexibility.

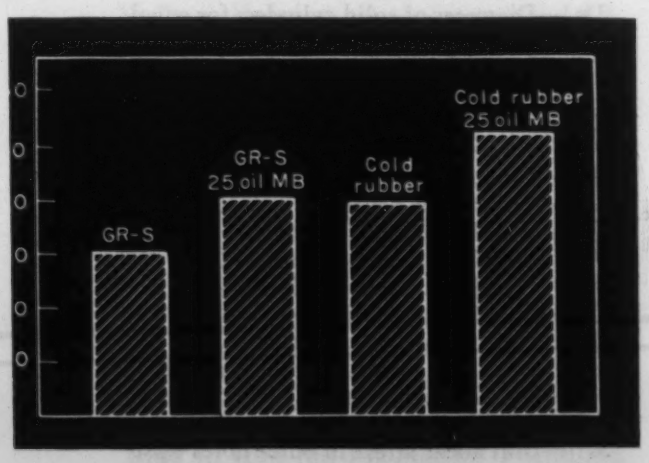
WHAT'S NEW IN Synthetic Rubber Modifications

by **KENNETH ROSE**, Mid-Western Editor, Materials & Methods

● THE PROPERTIES OF RUBBERS, both natural and synthetic, are considerably modified by variations in composition and processing techniques. Modifications of some of the familiar synthetic rubbers are proving of great value in extending the range of physical and chemical properties available to the materials engineer.

Blends of thermoplastic or thermosetting resins and synthetic rubbers have been produced and used for several years (MATERIALS & METHODS June, 1950). More recent modification techniques promise to effect even more significant changes in the application and economic status of synthetics throughout industry.

In general, synthetic rubber modifications are obtained in two ways: by blending, and by modification during the production process.



Relative tire tread wear ratings of various synthetics.

1. Blending Modifications

In this type of process, additives are blended with the rubber after it has been chemically synthesized. Blends of phenolic and vinyl resins with synthetic rubbers are typical. Used primarily with acrylonitrile and chloroprene types of rubber, resins serve principally as hardeners. Phenolic resins can be blended with butadiene-styrene synthetic rubbers, but lack of oil resistance in these rubbers limits the range of application and they are not as widely used as the oil resistant blends.

2. Modification During Production

The modification processes that take place *during* the actual chemical production of the synthetics fall into this category. Basic modification techniques now used in production include:

a. Oil extension
b. Variation in styrene content of GR-S types
c. Operational variables producing new properties
d. Variation in molecular weight

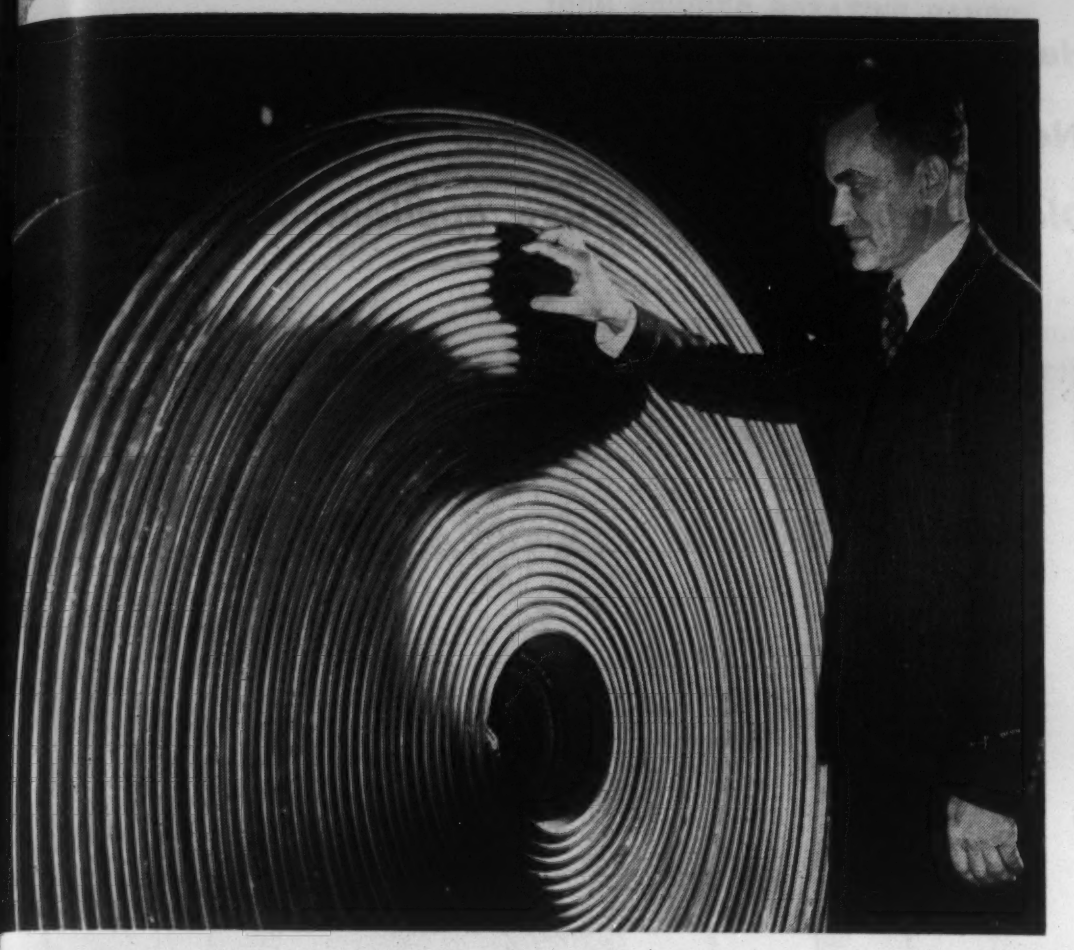
Each of these variables is responsible for a considerable range of differences in the final product, and when several factors are combined an even wider range of modifications is available. While the materials engineer need not be concerned with the chemical processes involved, the properties of modified synthetics are of direct importance.

Oil Extension

Oil extension of the synthetics is one of the most publicized modification techniques and is one of the most important from an economic point of view.

While butadiene-styrene copolymer rubbers are not oil resistant, it has been discovered that an emulsion of petroleum oil mixed with the latex or coagulated rubber becomes so intimately a part of the elastomer that the identity of the oil is completely lost. Rubbers of high molecular weight are used for oil extension modification in order to avoid excessive softening (see below). The amount of oil that can be added in this process is quite substantial; GR-S rubbers are extended with 25 to 50 parts of oil per 100 parts rubber, with one of the most common formulations containing 37.5 parts of oil per 100% of GR-S.

Oil extended rubbers are the same as pure GR-S in appearance. They



Tough, flexible rubber is produced by cold process described in text. Conveyor belts and tire treads are typical applications.

can be processed on conventional equipment, and it has been reported that workability is actually improved due to the tendency of oil to inhibit the formation of gel during processing. Oil extended GR-S has been successfully formulated for satisfactory tire rubber, indicating that abrasion resistance can be maintained. In general, resiliency is increased and some types of oil extended rubbers have better flexibility at low temperatures, particularly the butyl synthetics.

In the finished state, oil extended rubbers tend to take up oil more readily than unmodified types. For that reason oil extension is not used with rubbers intended for oil resistant use. Difficulties have been experienced with the adhesive bonding of oil extended rubbers, but this trouble has been substantially eliminated by using special adhesives.

The principal advantage of oil extended synthetic rubber appears to be in cost economy. The addition of 25 parts oil per 100 parts GR-S can lower material cost as much as 4¢ per pound (based on 23¢ per pound cost of high molecular weight GR-S).

Styrene Content Modifications

Increasing the proportion of styrene in GR-S produces a harder, tougher material. Decreasing the styrene content tends to reduce tensile strength and makes processing more difficult. However, when GR-S is produced by the cold process (see below), styrene content can be reduced to 20% without appreciable change in character. Because of the butadiene supply situation it is now standard practice to formulate GR-S for the cold process with 23½% styrene.

Specialty rubbers are produced in a wide range of styrene contents. Low styrene formulations of 3, 8, 12% and so on, are available and offer the advantage of good low temperature flexibility. An all butadiene synthetic rubber has been produced, its odorless quality establishing it as an important product for use in foam rubber for upholstery and bedding.

High styrene copolymers containing 43, 46 and up to 85% styrene are produced largely for manufacture of shoe soles and for use in applications requiring extremely hard, tough rubber.

Operational Variables

Variations in operating temperature and the use of catalysis to speed polymerization result in significant differences in physical characteristics and production costs of synthetic rubbers.

The cold process of polymerization, in which the reaction temperature is held at 41 F rather than 122 F usual in GR-S manufacture, produces a rubber of such superior strength and abrasion resistance that installation of expensive refrigeration equipment in GR-S plants has been economically justified.

Recent discovery of catalysts to speed polymerization has reduced the time required for cold process reaction from approximately 12 hr to about 20 min. This has already resulted in significant cost reductions, and the short reaction time raises the possibility of continuous production of cold process synthetic rubber in pipe coils rather than by batch in reaction vessels. Such a process would greatly reduce the amount of equipment necessary for production, but for the present, use of installed refrigeration equipment is sufficiently economical.

Molecular Weight Variations

Higher molecular weight in synthetics results in greater stiffness and is usually indicated by higher Mooney viscosity.

When rubber is harder as synthesized, it can be softened by greater amounts of plasticizer, which in turn permits the use of more filler, thus lowering the material cost. High molecular weight GR-S, as mentioned previously, is indicated for use with oil extention modifications. Some types of chloroprenes, among other synthetics, are compounded in higher Mooney grades to permit the use of more plasticizer and cost-reducing filler.

Combinations of Modifications

While modification techniques have been discussed in terms of their individual effects, it is highly practical and sometimes necessary to combine several modifications in order to produce a synthetic rubber of proper physical characteristics at an economically competitive cost.

For instance, a synthetic produced by cold catalysis can have much lower styrene content without loss of desirable properties of toughness and tensile strength. Tests show that tire treads of cold GR-S extended with 25% oil during coagulation were equal or slightly higher in rating than treads containing regular cold process unmodified stock (see bar chart).

PICTURE CREDITS: United States Rubber Co., Goodyear Tire & Rubber Co.

Materials at Work

Here is materials engineering in action . . .

New materials in their intended uses . . .

Older, basic materials in new applications . . .

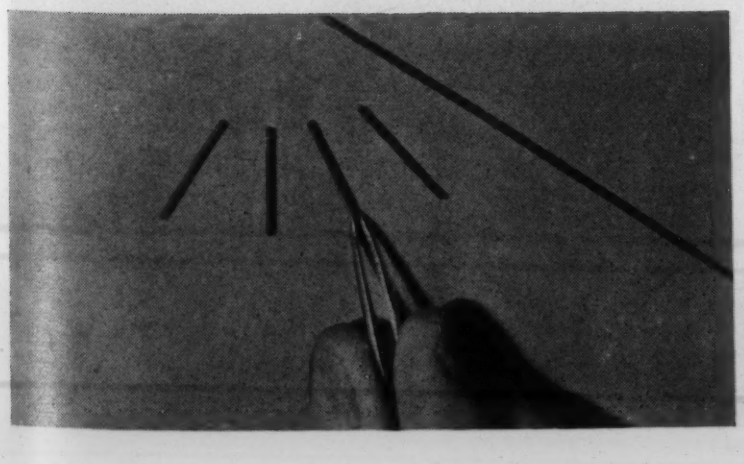
SILICON STEEL CORE FOR POWER TRANSFORMERS A precut, preformed core for small power transformers that improves performance and reduces transformer size and weight has been announced by the General Electric Co.'s Power Transformer Dept.

With this preformed core, made of oriented, cold-rolled silicon steel, G-E engineers say they have a greater amount of flexibility in designing some of the important characteristics of a transformer. The losses, exciting current, noise level, weight and dimensions can be varied to best suit the user's operating conditions, it was reported. This is done by using a minimum number of joints, an annealing process which removes mechanical strains introduced when the core is formed, and a unique clamping structure.

In manufacturing the core, cold-rolled Corisil steel laminations are cut in progressively decreasing lengths by an automatic shear and are then stacked into a ring. A hydraulic press forms the ring into a rectangular shape. After being securely banded in this shape, the core section is annealed in an electric furnace to permanently fix its shape and to remove strains. In the final assembly, two core sections are bolted together and supported in a special clamping structure designed to prevent strains on the laminations.

IRON POWDER ROTATING BANDS

Important savings in strategic materials such as copper are made possible by use of a special iron powder process in the manufacture of rotating bands for 90-mm shells by the Amplex Div. of Chrysler Corp. Two Oilite iron powder rotating bands such as those pictured above are used on each shell to assist the rifling inside the gun barrel in providing the spin necessary for range, accuracy and stability in flight. It is estimated that in processing Iron Oilite rotating bands for 1,000,000 of the 90-mm shells, 460,000 lb of copper can be saved and made available for other requirements. The iron powder bands are formed to exact dimensions in a special press and no machining is necessary, as in the manufacture of tube-formed bands.



TITANIUM TUBING PRODUCED IN UNUSUALLY SMALL SIZE

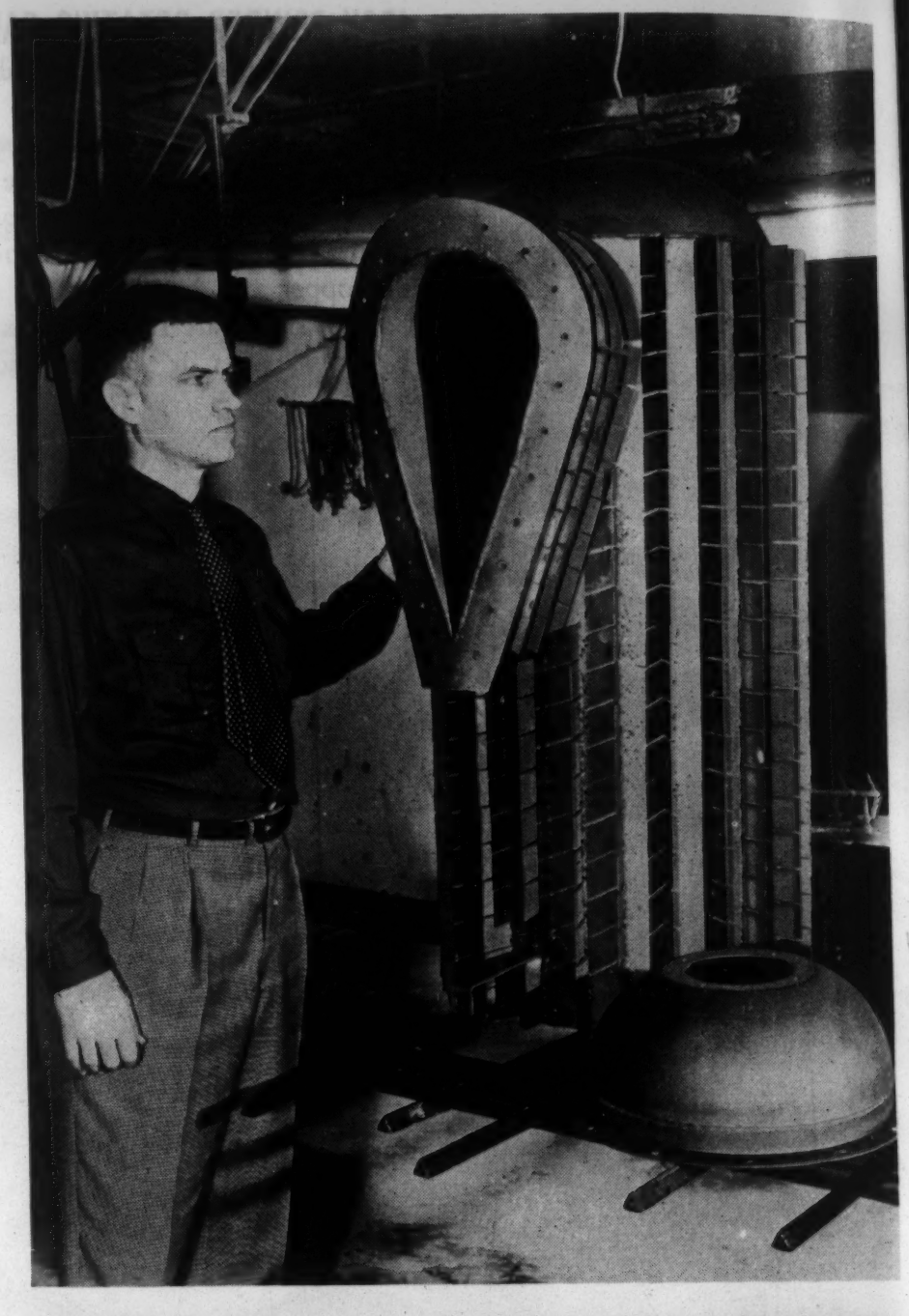
The smallest size tubing drawn from commercially pure titanium is being produced by Superior Tube Co. Outside dia is only 0.0455 in.; wall thickness is 0.00225 in. At present, this tubing is used for experimental work in the electrical, electronic and chemical industries. Shown are several experimental cathodes produced by Superior for the electronics industry, together with a random length of tubing. Availability of this small size is expected to create new applications for titanium tubing in many fields.

CERAMIC COATED COMBUSTION CHAMBER

Using high temperature ceramic coatings originally developed for jet engine parts, the Hartzell Propeller Fan Co. has improved combustion efficiency and heat transfer in this combustion chamber, which is part of its crop drier. The coating is applied by Barrows Porcelain Enamel Co.

The main part of the chamber is 18 in. in dia and 60 in. long. Fins protruding from the outer shell increase overall efficiency. A secondary shroud heat exchanger completely surrounds the forepart of the drier, and adds over 60 sq ft of radiation area to the drier unit.

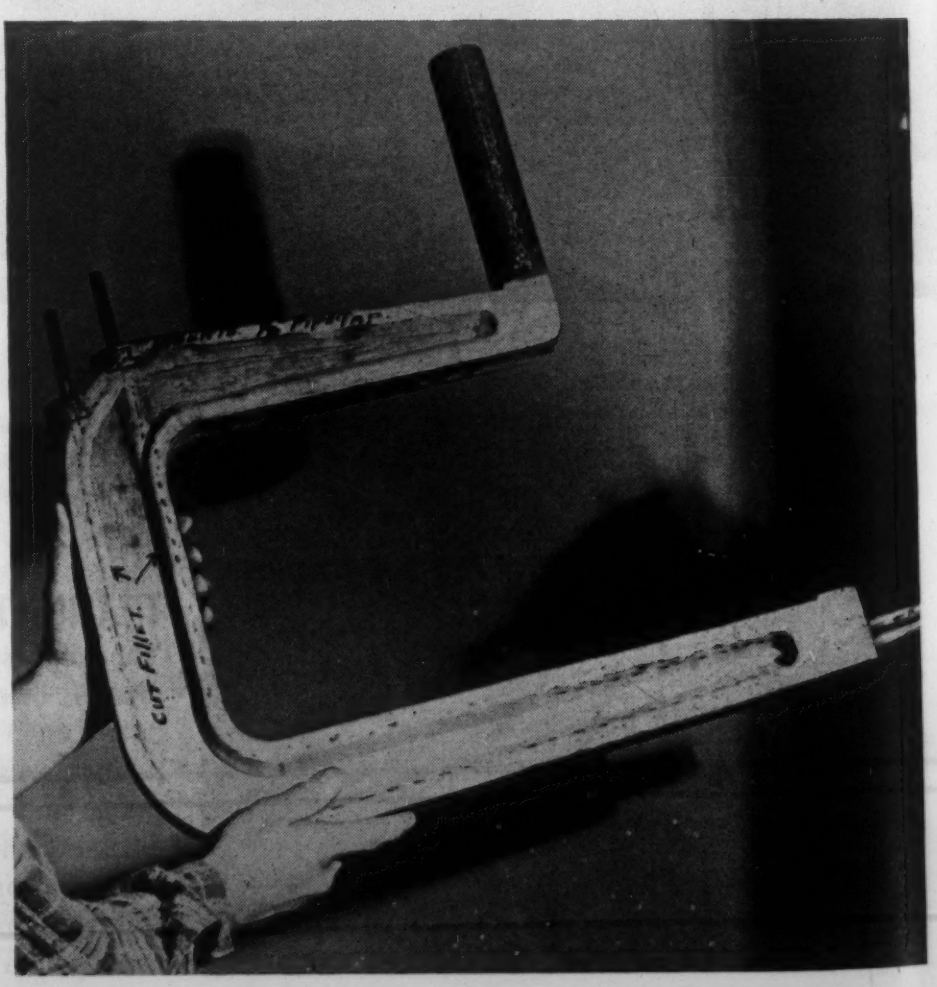
With the ceramic coating, the drier can be run for extended periods at temperatures ranging from 1000 to 1400 F. Mild steel used as the base metal is protected by the coating from scaling and physical breakdown. Fins, shroud and chamber are all coated in successive firing operations. Thicknesses range from 0.002 to 0.003 in. on all surfaces. Numerous welds are also coated.

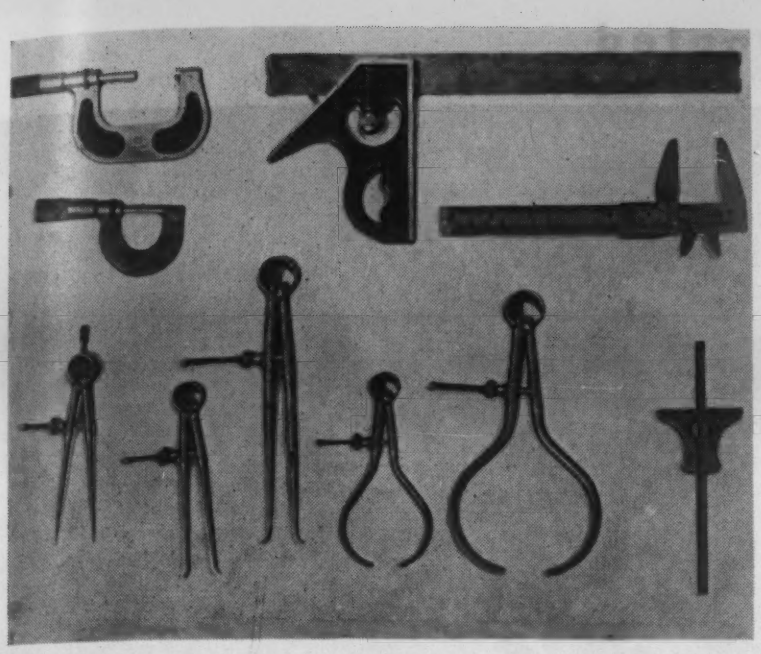


NICKEL TUBING IN SPOT-WELDING YOKE

Electrode tips for spot-welding machines can burn rapidly unless water-cooled. The spot-welding yoke illustrated is one of many types made by Philadelphia Bronze & Brass Corp. Two lengths of Superior Tube Co. nickel tubing, $\frac{3}{8}$-in o.d. by $\frac{1}{4}$-in. i.d., convey water to-and-from the end of the spot-welding yoke on which the electrode tip is placed. The hollow electrode tip fits over a brass tube which is screwed into the end of the yoke through which water to cool the tip flows.

Body of the spot-welding yoke is Mallory 3 (chromium copper) alloy, which is poured at 2200 F. To meet the requirements of the application, specifications call for either nickel or Inconel tubing inside the spot-welder yoke. Both materials are nonrusting and are unaffected by the chromium copper alloy at the pouring temperature. At present, the foundry uses Superior's seamless nickel tubing, fully annealed, in preference to Inconel because it is more readily available.





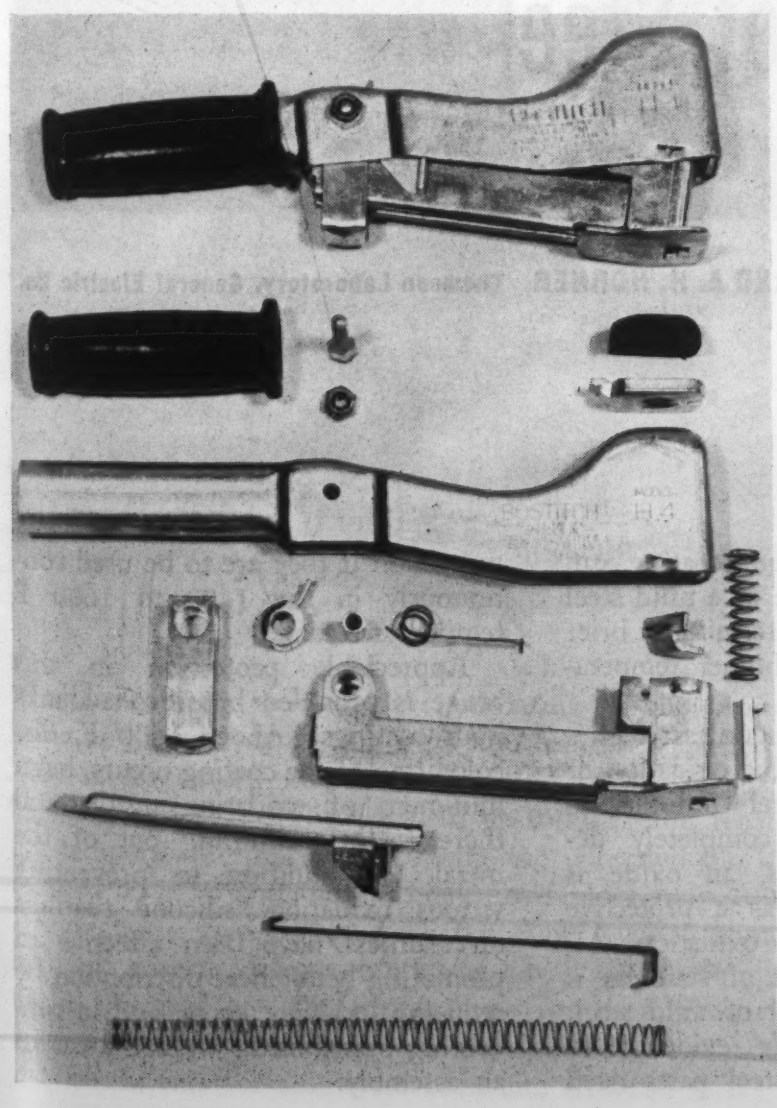
VACUUM FORMING TECHNIQUE PRODUCES STRONG AND DECORATIVE PLASTIC PACKAGES

Contour packaging is a vacuum forming process developed by the Auto-Vac Co. Essentially a combination of heat and pressure, the vacuum forming method reproduces shapes with speed, low cost, and fidelity. These advantages are applied to the packaging of precision instruments where protection is the chief requirement. Reproducing shapes faithfully, vacuum forming allows the instrument to be snugly imbedded in its container, affording a maximum safeguard against physical damage. This same snug fit protects Quartermaster rations, appliances and golf balls.

Polystryene, modified styrenes, polyethylene, acetate, butyrate, and all vinyl polymers have been successfully shaped by vacuum forming. It is adaptable to the weight and nature of the object to be packaged; sheets of almost any size in thicknesses from 0.001 to 0.125 in. can be vacuum formed without noticeably affecting the basic strength of the material.

MANY MATERIALS IN STAPLER

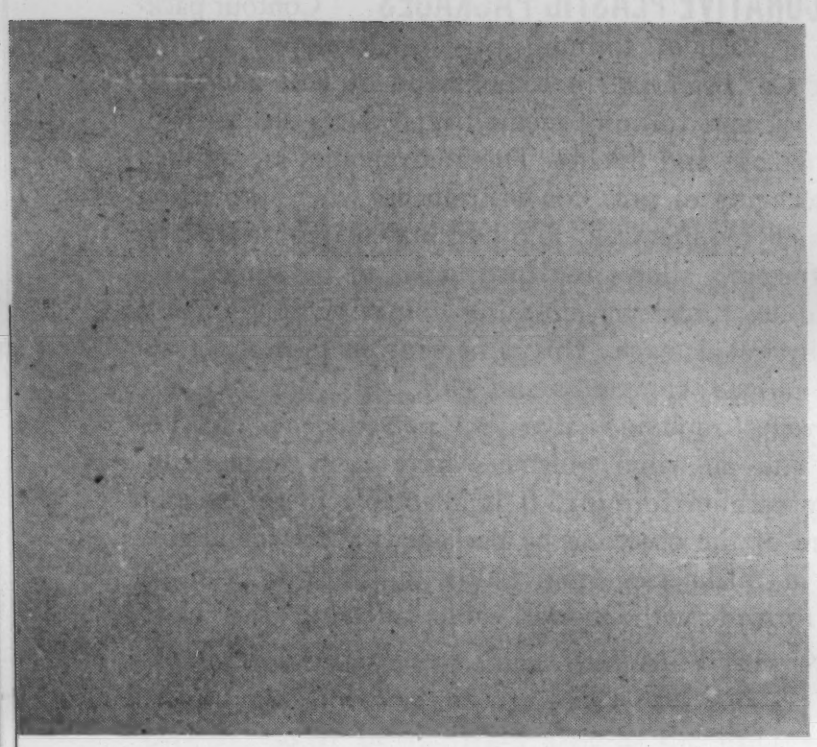
Of the line of stitching and stapling machines manufactured by the Bostitch Co. for the fastening of nearly all materials softer than unhardened cold rolled steel, the Model H4 was developed particularly for use as a roofing hammer. Since a hammer of this type slams the staple through the material at high speed and is stopped instantaneously when the crown of the staple hits the work, the selection of the material for the driver and former had to be made very carefully.

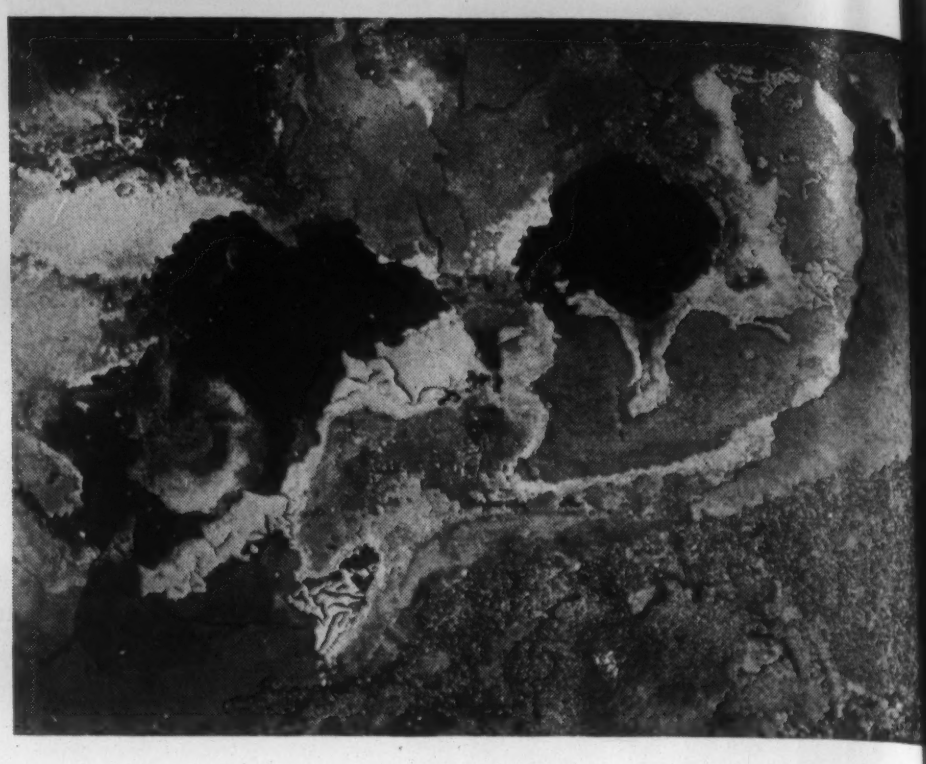


It was found that special silicon-manganese steels contain the necessary resistance to the high impact of the hammer, with the extent of heat treatment varying in proportion to the thickness of the tongue. Formers are usually made of case hardened low carbon steel, with the surface well over Rockwell C 62. Most of the frame members, such as the handle and magazine, are made of low carbon cold rolled steel of the best available deep drawing quality, since the material must be drawn into shape without fracture or loss of strength. The steel must respond to case hardening and the core must retain high structural strength.

Since roofing hammers are subject to various atmospheric conditions and excessive moisture, they must resist corrosion. The high material cost prohibited the use of stainless steel; therefore, several types of electroplates were tried. With the possible exception of chromium, cadmium plating has been found to be the best from the standpoint of rust resistance and low-friction requirements. The objection that cadmium plating has a slight tendency to rub off on the hands is overcome by the addition of a properly compounded rubber grip.

Other materials are also important in the construction of a hammer. For example, a rubber bumper is needed to absorb residual energy after the staple is driven home. If it is too soft, the staple crown will be buried too deeply in the material; if it is too hard, the bumper or the surrounding steel members will fracture. Roofing hammers are subjected to severe dirt conditions, the most troublesome being the tendency to pick up asphalt and ground slate from the surface of the shingle. Usually the hammer is cleaned by dipping in a can of kerosene or some other solvent, and the manufacturer must select a material that will not deteriorate because of these conditions.





After 280 hr. at 1020 F, these mild steel panels show how.....

Silicone-Aluminum Paints Stretch High-Temperature Life of Steel

by A. E. DURKIN AND A. H. HORNER, Thomson Laboratory, General Electric Co.

● THE PROPER USE of aluminum-pigmented silicone coatings can help manufacturers of high temperature equipment extend its life, cut costs of materials and fabrication, and conserve strategic materials.

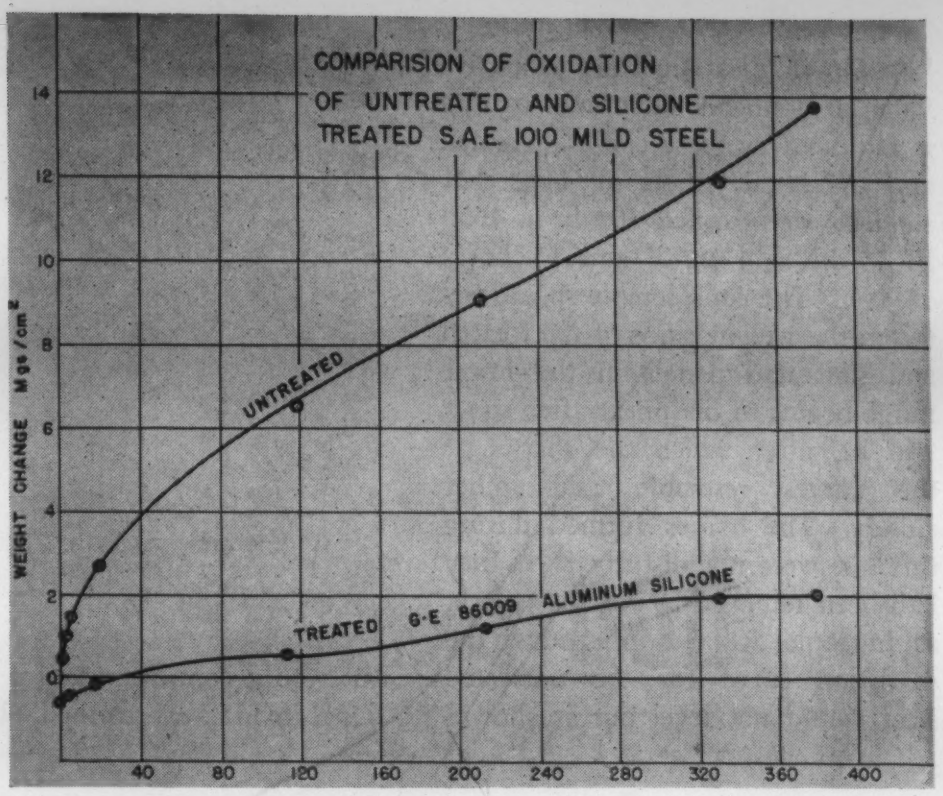
Tests show that silicone-aluminum paints will withstand any temperature condition where structural considerations permit the use of mild steel. The limiting factor of the mild steel-silicone system is the steel, not the coating. Thus, silicone-coated mild steel can be substituted for stainless steel in apparatus that operates up to and including 1000 F.

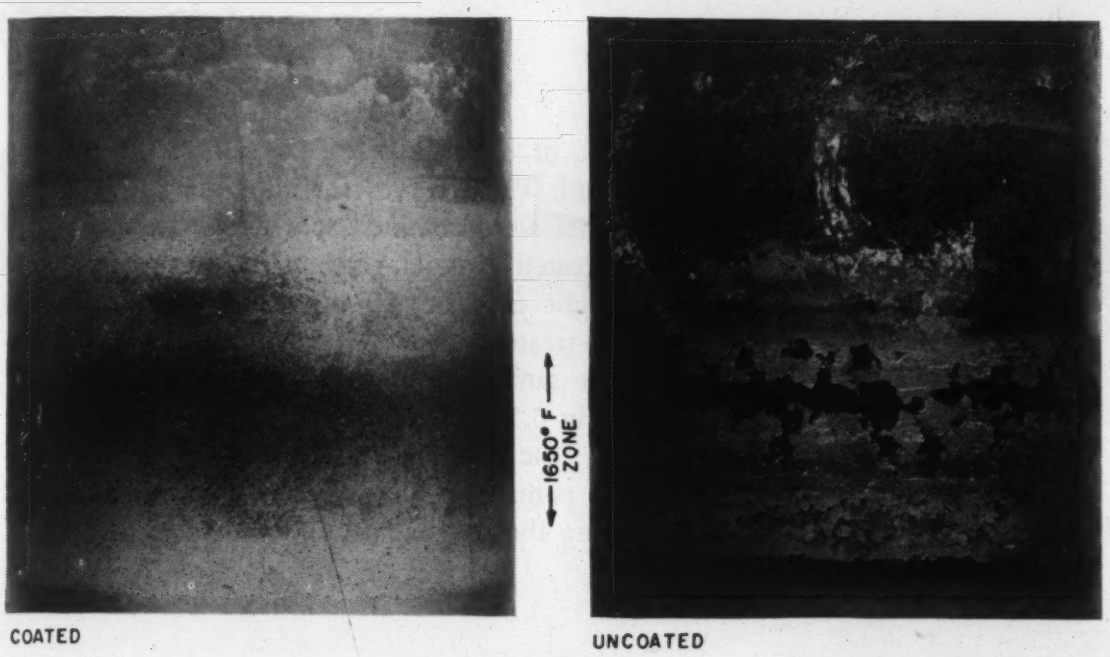
A silicone-aluminum coating can also lengthen the life of a mild steel part subjected to intermittent brief exposures to much higher temperatures.

The oxidation of stainless steel is quite different from the oxidation of mild steel. Mild steel continues to oxidize until it is completely destroyed. In stainless, an oxide is formed which acts as a protective barrier against further oxidation. Although the oxidation of stainless is not as critical as that of mild steel, there is considerable evidence to show that stainless steel parts need protection if they are to be used continuously in the 1400 to 1600 F temperature range.

Appreciable protection in this range is provided by silicone-aluminum coatings. Above 1600 F, discoloration of the coating occurs, but a minimum of oxidation results and there is little thinning out of the metal. In addition to preventing serious oxidation, silicone coatings on stainless have been effective in promoting better heat distribution by reducing local hot spots, and in preventing oxidation at welded areas in an assembly.

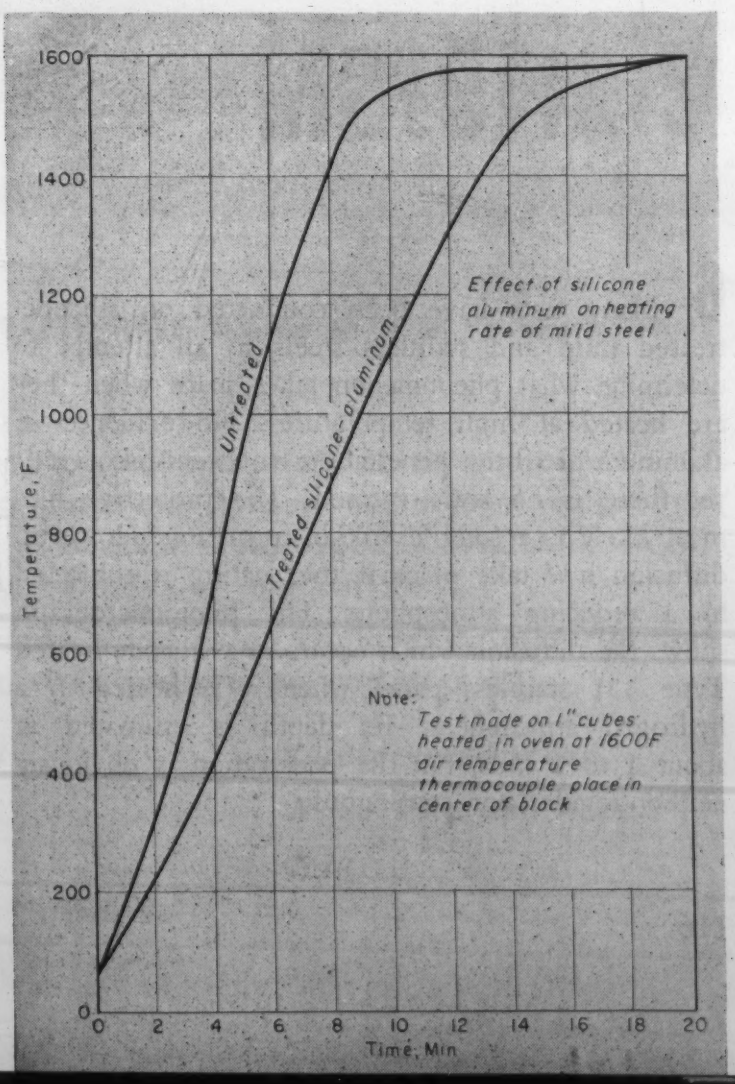
1 Mild steel, protected with a silicone-aluminum coating, can be used in temperature ranges where it would ordinarily have oxidized to failure. Oxidation curves for a temperature of 930 F are shown here. At the completion of the test the untreated panel had increased in weight by 14 mg per cm² and was still gaining, whereas the protected panel had leveled off at 2 mg per cm². Similar tests have been run for 1000 hr with no breakdown of the finish. (The weight gain data corresponds with other published data on the oxidation of steel at this temperature.)



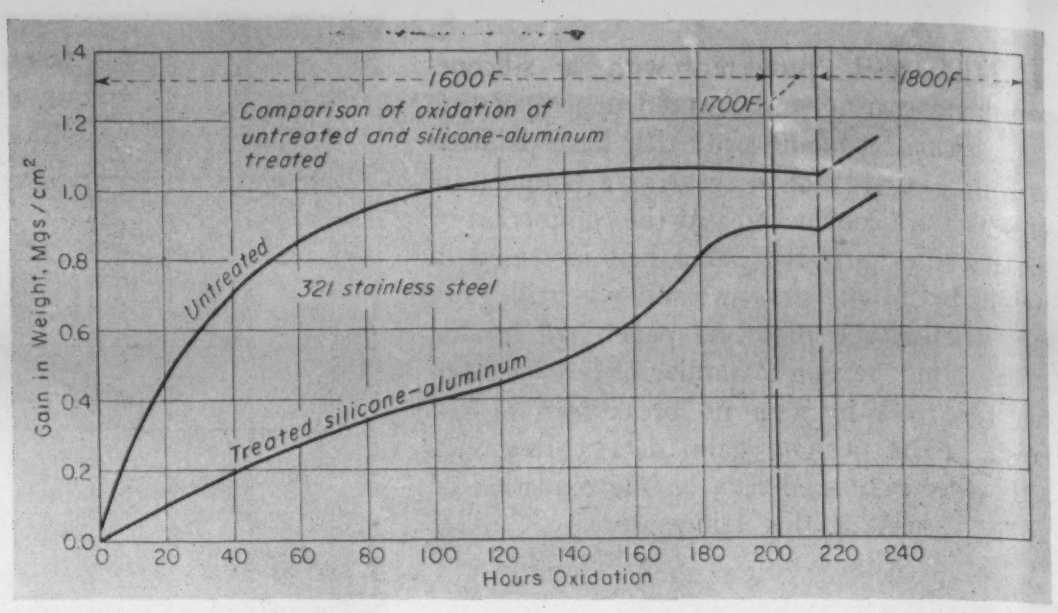


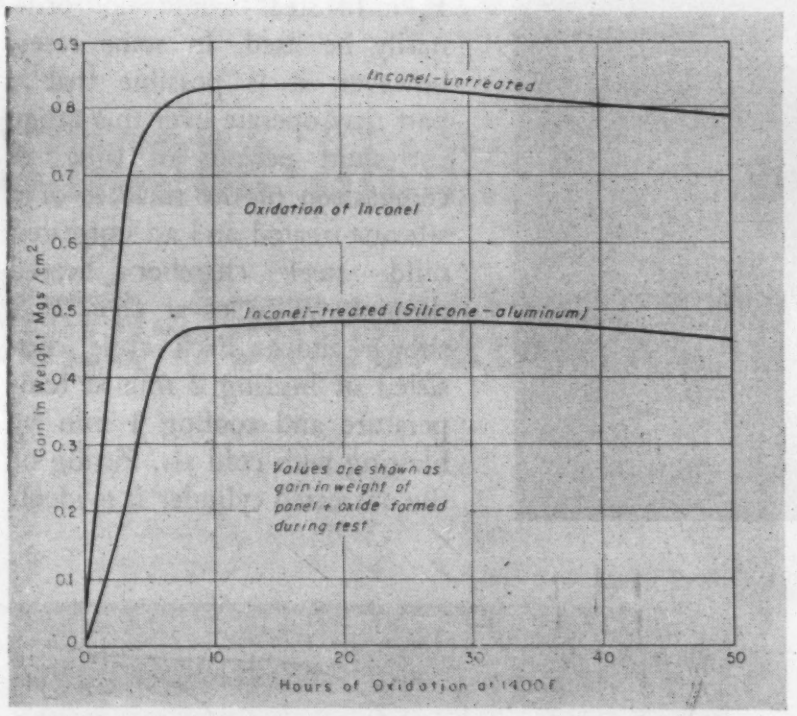
2 For temperatures over 1000 F, mild steel would not ordinarily be used. In some cases, however, it is possible that a part may operate over this range for short periods of time. A comparison of the surfaces of a silicone-treated and an untreated mild steel chamber heated through 20 cycles at 1650 F is shown above. Each cycle consisted of heating 2 min at temperature and cooling 1 min by blasting with cold air. Pitting of the untreated cylinder is evident.

3 Undoubtedly one factor contributing to the protective value of the silicone coating is its heat transfer characteristics. The curves shown here were obtained by placing sample blocks of steel in a furnace held at 1600 F, and recording the temperature rise. After 10 min the untreated block had reached 1550 F and the silicone-treated block only 1095 F. Although the two curves reach the same level in about 20 min, the coating appears to offer an advantage for equipment to be operated at high temperatures for short time cycles. (These data are consistent with emissivity and heat transfer coefficients for aluminum films and oxidized steel.)



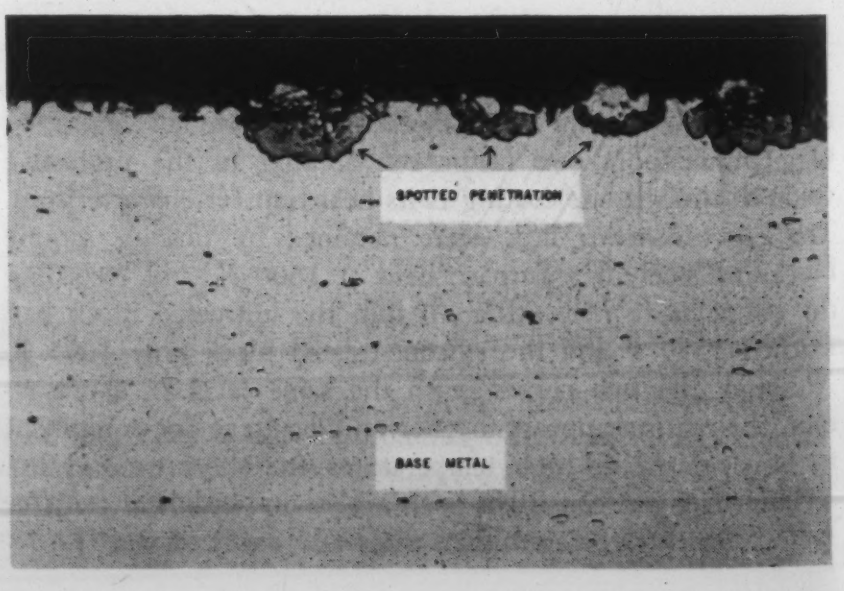
4 On stainless steel the protective value of a silicone-aluminum coating is indicated by these curves. Treated and untreated panels of Type 321 stainless were heated 203 hr at 1600 F. 15 hr at 1700 F and 15 hr at 1800 F. The considerable spread between the weight gains of the treated and untreated panels in the lower range begins to disappear after about 180 hr, after which the shapes of the curves resemble each other closely. The oxides formed during this test were not disturbed. If they had been removed by thermal shock, as in some actual applications, the oxidation curve for the untreated steel would not level out as shown, but would continue upward as additional oxide was formed. Then the value of the silicone coating would become more evident.

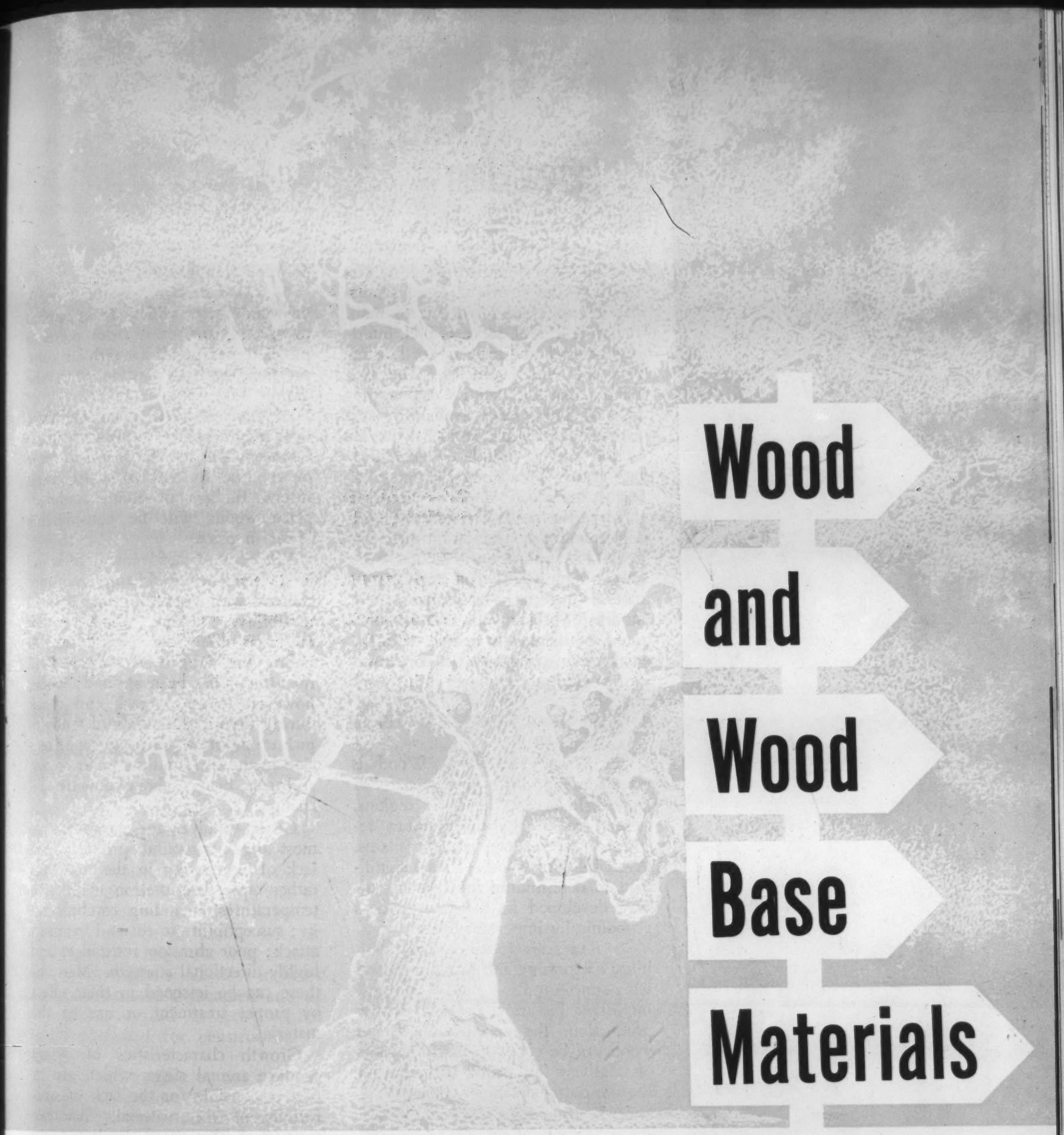




5 The life of other heat resistant alloys can be similarly extended. These curves for untreated and silicone-coated Inconel were obtained at a temperature of 1400 F. The untreated Inconel reached its maximum oxidation—a weight gain of 0.8 mg per cm²—after 8 hr. The silicone-treated Inconel reached its maximum oxidation in the same time interval but its average weight gain was only 0.5 mg per cm². (In all the curves presented here, the weight gains represent the weight gains of the panel plus the weight of any oxide which formed during the test but dropped off the panel.)

6 Many tests have been conducted on silicone-treated mild and stainless steels in an attempt to determine what phenomenon takes place when they are heated at high temperatures. No evidence of aluminum or silicon penetration has been discovered; yet there is no scale formed. The protective film most likely is a complex oxide formation. However, diffusion *will* take place if the coating is subjected to a reducing atmosphere. The photomicrograph shows the diffusion which occurs in a silicone-treated Type 321 stainless panel when it is heated in a hydrogen atmosphere. Its depth is estimated at about 1 to 2 mils, but the penetration is obviously neither regular nor continuous.





Wood and Wood Base Materials

by KENNETH ROSE, Mid-Western Editor, Materials & Methods

MATERIALS & METHODS MANUAL No. 97

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

SEPTEMBER 1953

Wood, one of man's oldest materials, is still one of his most important engineering materials. Modern technology has greatly broadened the range of forms in which wood is available, which, in turn, has multiplied its fields of application.

This Manual reviews wood as an engineering material and covers the properties, sizes and grades, and uses of:

- ***Commercial Wood***
- ***Laminated Wood***
- ***Modified Wood***
- ***Reconstituted Wood***
- ***Wood Pulp and Paper***
- ***Cork***

Introduction

Wood, the dignified cellulosic material in the stems of large plants, has always been important to man. It has, and does, serve as fuel, building material, and material for fabrication into small articles. The two factors that dictated its use in prehistoric times, ready availability and ease of fabrication, influence its selection today. Modern technology has greatly broadened the range of forms in which wood is available to serve the needs of mankind, and, correspondingly, has multiplied its fields of application. Wood is no longer simply the cut and shaped natural material — it is laminated, modified, broken up and reconstituted, or chemically treated, with the goal of better properties or lower cost to guide the engineer in his work with it.

Wood has the following qualities to recommend it:

1. *Wide availability.* Wood is found in abundance in most parts of the world except the polar regions, desert areas, high mountainous regions, and a few treeless plains. Availability of wood has been significant in determining the type of culture developed in the past, and is economically important today.

2. *Ready workability.* The possibility of forming and fastening wood with simple tools is one of its most important features. Even in factory production, the speed with which wood can be cut with machine tools of relatively low power consumption is an important factor in its selection.

3. *Light weight.* Wood, with a specific gravity of about 0.40 to 0.45, weighs less than 1/4 as much as magnesium, the lightest structural metal. This light weight can be translated into greater stiffness by using the material in thicker sections.

4. *Beauty.* The attractive appearance of natural wood has always been an important consideration in its selection. Even where structural requirements dictate the use of metal, wood-faced sheet steel is sometimes used to bring the natural beauty of wood grain to the composite. The practice of painting a wood grain on steel, or of coating with a paper upon which a wood grain has been reproduced, is a recognition of the value of wood grain beauty.

5. *Good strength.* While strength of wood varies widely from species to species, and even from piece to piece, it has good strength in compression, and in tension with the grain.

6. *Low cost.* If calculated to a "per pound" basis, the price of most cabinet woods will be found to come quite close to that of sheet steel. Rough timbers of more commonplace woods will be considerably lower in price.

The greatest disadvantage of wood is its tendency to change moisture content, with a resulting dimensional instability. "Green" wood, as cut, must be dried out before use to reduce the danger of warpage and rot after it has been applied; wood, however, tends to crack and check during drying. Dried wood tends to pick up moisture when the vapor tension in the surrounding air increases, and this brings about dimensional change.

Other disadvantages, common to most organic natural products, are lack of uniformity in the material; rather rapid deterioration at elevated temperatures, including combustibility; susceptibility to rot and to insect attack; poor abrasion resistance, and highly directional strength. Many of these can be lessened in their effect by proper treatment or use of the material.

Growth characteristics of wood produce annual rings, which are in part responsible for the lack of uniformity of the material. Another feature of the wood in log form is the differentiation into *sapwood* and *heartwood*. The former is the unusually lighter-colored wood just inside the bark and cambium layers of the tree, and the latter is the older, dense, inactive wood that forms the bulk of the tree trunk in most species. The differentiation is of economic importance because the light-colored sapwood is in general less dense, less resistant to rotting, less resistant to insect attack, and less durable than heartwood. It also requires more work in staining to match the darker heartwood where a streak of sapwood appears in a decorative piece. In hickories, maples,

and many "white hardwoods", sapwood forms the bulk of the log.

Knot. The buried traces of branches, are usually points of weakness in the wood, and may cause difficulties in painting; however, they can sometimes be utilized in decorative effects.

Grain originates with the cellular structure of wood, and is important from the standpoint of both appearance and utility. Straight-grained woods, which include most of the conifers, will usually split easily in a radial direction, but may be quite resistant to bending or breaking. Cross-grained woods are frequently highly resistant to splitting and breakage, but the sawn lumber will usually show some diagonal direction of grain, with resulting weakness. Stock of maximum toughness, such as would be required for airplane stock, or for axe-handles, is prepared by selecting straight-grained stock and by splitting the wood rather than by sawing it.

Wood As Lumber

In any discussion of wood as a material, three terms are sure to occur. *Wood, timber,* and *lumber* have various meaning, and are to some extent used interchangeably. *Wood* is usually used to mean the material as such, and is also used to designate a forest or other stand of trees. *Timber* can mean either a standing growth of usable trees or comparatively large cut and shaped structural members. *Lumber* includes both such structural members and all cut and prepared or semiprepared wood intended for construction or industry.

After the cutting of the tree and occasionally removal of the bark from the log, the log is sawed into boards or into cants or other heavy timbers. When production of veneer or plywood is intended, the log may be rotary-cut. *Plain-sawed lumber,* produced by most cuts in "through and through" sawing, is the most economical in time and material, while *quarter-sawed lumber,* obtained by radial or near-radial cuts, is less likely to show checks, warps, and other distortion in drying. Peeling or slicing produces veneers that can be dried more easily and uniformly.

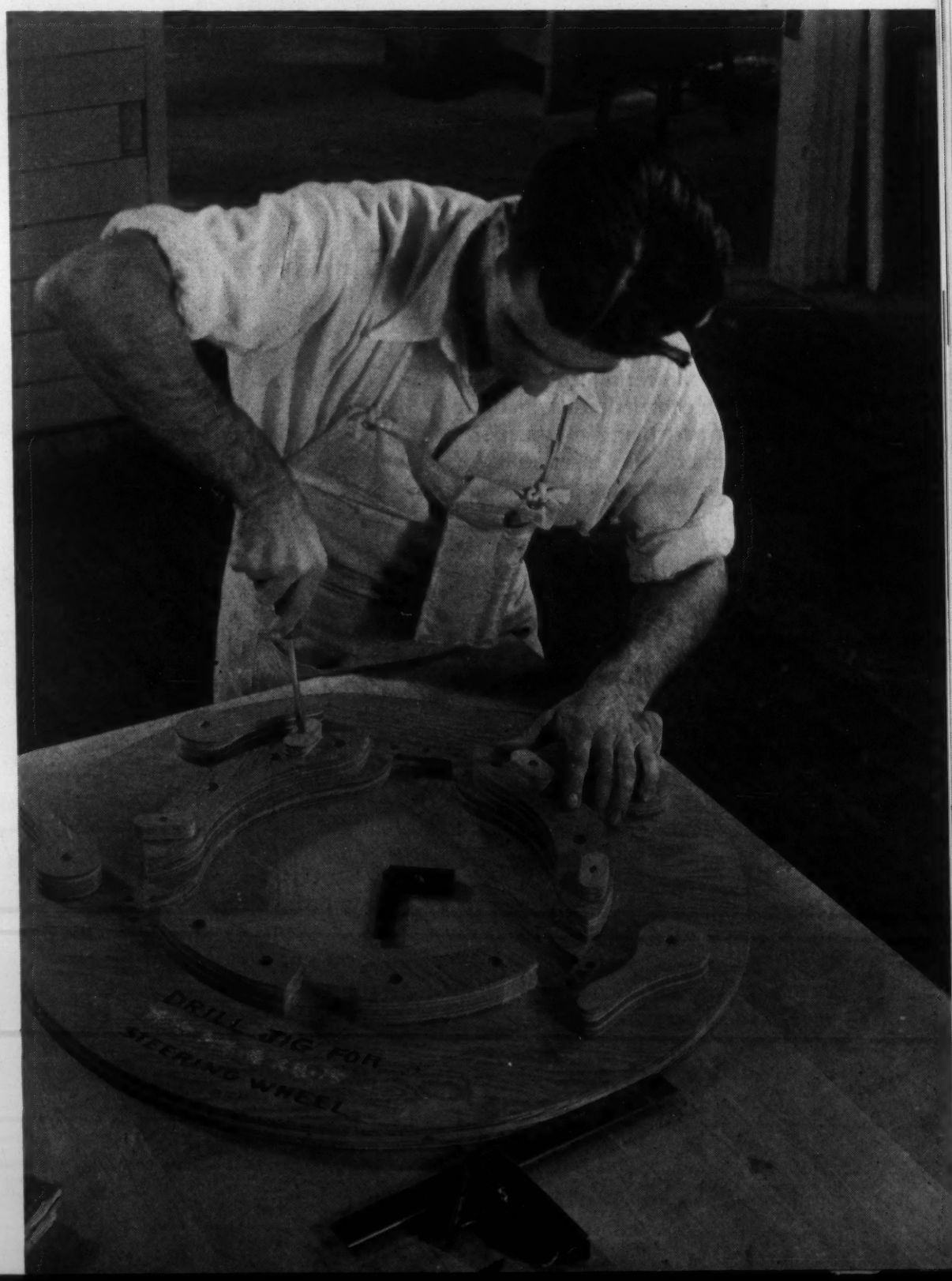
Freshly cut lumber contains a large amount of water, ranging from 30% to more than 200% of the dry weight of the wood. Such *green lumber* will shrink considerably as it dries, and so is unsuited for joinery or other precise work. The high moisture content would interfere with painting, gluing, or preservative treatment, and would make it more susceptible to attack by fungi and insects, so little lumber is used in the green state. *Seasoned lumber* retains about 10 to 15% moisture after air-drying, and about 6% after kiln-drying. Seasoning of lumber causes shrinkage, and in kiln-dried stock this might be as much as 5 to 10% in the tangential direction. Shrinkage in the radial direction will be about 3 to 7%, and in the length of the lumber the shrinkage may be about 0.1 to 0.3%. The greater tangential shrinkage causes some radial cracking or checking during seasoning.

While most lumber is air dried, drying by artificial heat is becoming increasingly important. Kiln-drying will accomplish in days or months what air-drying would require months or years to do, and the product is less liable to shrinkage in use, and better adapted to gluing and painting.

The rotting of wood takes place most rapidly when the moisture content is about 20% or a little higher. If the wood has been properly seasoned so that the moisture content is below 15%, and the surface coated with a paint, varnish, lacquer, or enamel, there is little danger of rotting. Paint films are more pervious to water than is generally realized, but the presence of the protective film does considerably reduce absorption of moisture.

Wood can be impregnated with preservatives to obtain greater resistance to rotting. Preservatives are applied by brushing, dipping, spraying, or under heat and pressure. If the wood is to be used in the soil—for posts, pilings, or railroad ties,

Plywood used to make a jig for steering wheel going into Boeing passenger aircraft.



or under water—for pilings or dock structures, and painting is not necessary; coal-tar creosote is the preservative most used. It is oily in nature and so is resistant to leaching. Its dark color and oily nature interfere with painting, but for some purposes it can be used in connection with a variety of color stains compatible with creosote.

Other organic preservatives are available, with pentachlorphenol the most popular. Being colorless, it can be used under paint; drying time for the preservative is somewhat long. Inorganic preservatives are useful—zinc chloride solution, especially when applied under pressure, finds wide application. Oleates and naththenates of copper are other commercially used preservatives for wood.

The unit of measure of timber and lumber is the board foot—a piece of lumber one foot long, one foot wide, and one inch thick. The usual unit of sale is 1000 board feet, abbreviated M. Sawed lumber nominally one inch thick will usually be slightly under this thickness as supplied to the user. Rough sawed boards may be about 1 in. in thickness, and planed stock may be 25/32 in. thick. Stock between 3/16 in. and 1 in. in thickness is considered as one inch thick.

Heavy timbers and poles are usually sold by the linear foot, with section dimensions or diameter specified and piece length given. Ties, posts, and similar miscellaneous products are sold by the piece.

Veneer and stock under 3/16 in. in thickness are usually sold by surface measure, with thickness specified. Plywood is sold by surface measure, with thickness specified.

Small-diameter stock, such as firewood and pulpwood, is sold by a cubic measure called the cord, which is a stack of four-foot pieces four feet high and eight feet long.

Special stock of such kinds as excelsior stock, pencil stock, and special veneer pieces is sold by cubic measure. Certain imported woods, such as balsa, are sold also by cubic measure.

A few unusual woods, such as lignum vitae, and occasionally teak, are sold by weight for most applications.

Important Commercial Woods

A practical basis for classification of woods follows the botanical classification of plants. The plants that bear their seeds on small cones are called gymnosperms. These are usually referred to as the *conifers,* and with less precision as the evergreens. As they usually have a rather soft woody structure, they are sometimes called the softwoods. The angiosperms, flowering plants, include the monocotyledons, which are for the most part plants of small size or of no interest as producers of wood, and the dicotyledons. The latter includes many small plants as well as large trees. The woods are frequently called *dicotyledonous* or *deciduous.* Although the woods from some species are no harder than those from the conifers, they are all usually called the *hardwoods.* With recognition of the inexactitude of the terms, the woods from the conifers are termed coniferous, or softwoods, and the woods from the dicotyledons are called deciduous, or hardwoods.

The Softwoods

Eastern White Pine, Sugar Pine, and *Western White Pine* — These three types of woods are grouped together. All are swiftly growing species, with nearly white sapwood and slightly pink-tinged heartwood. The wood is light in weight, easily worked, with inconspicuous grain. It dents and breaks readily, is not durable, and has little rot-resistance. Old trees yield valuable "clear" lumber (free from knots and blemishes). Second-growth pine usually contains many knots, and is highly resinous and difficult to paint over unless sealed with shellac or special sealers. White pine is used often where strength is not essential—for foundry flasks and patterns, small woodwares, matches, furniture and panelling, boxes and crates.

Longleaf Pine, Loblolly Pine, Slash Pine, Norway Pine, Western Yellow Pine or *Ponderosa Pine,* and *Jeffrey Pine*—These are all types of yellow or hard pines. The wood is pitchy, quite hard in the Longleaf species and in a few others, and has a pronounced grain in these species. Ponderosa Pine is a massive tree, the wood from which is sometimes sold as California White Pine. For best resistance to wear, yellow pines should be rift-sawed—for heavy timbers, railway car construction, concrete forms, flooring, roofing and siding, boxes and crates, etc.

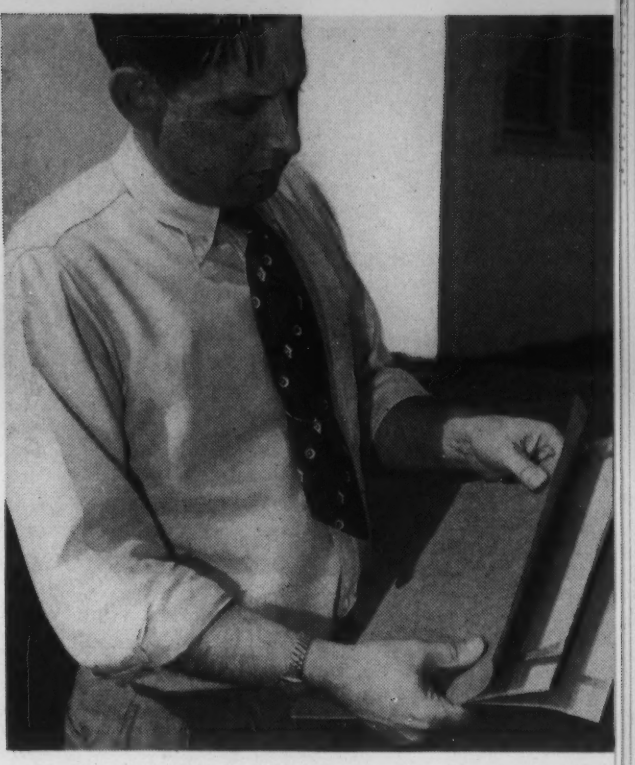
Douglas Fir — Sometimes called Oregon Pine, this is the dominant single species of timber in the United States. The wood is usually light and strong, but density may be rather variable. Massive timbers can be cut from good stands of trees. The wood is pale pink, becoming pale yellow upon seasoning. It has a striking grain. Pitchpockets occur rather frequently, and it has a tendency to splinter. It is used for bridges, masts, veneers, silo and pipe staves, boat building, etc.

Sitka Spruce, Eastern Spruces— While the Sitka Spruce of the Pacific Northwest has resilience combined with light wieght, and is a valuable wood for several important types of construction, the eastern spruces are usually small trees most useful for pulping. The wood is light in color, soft, not strong. It finds use in aircraft construction, paddles, spars, etc.

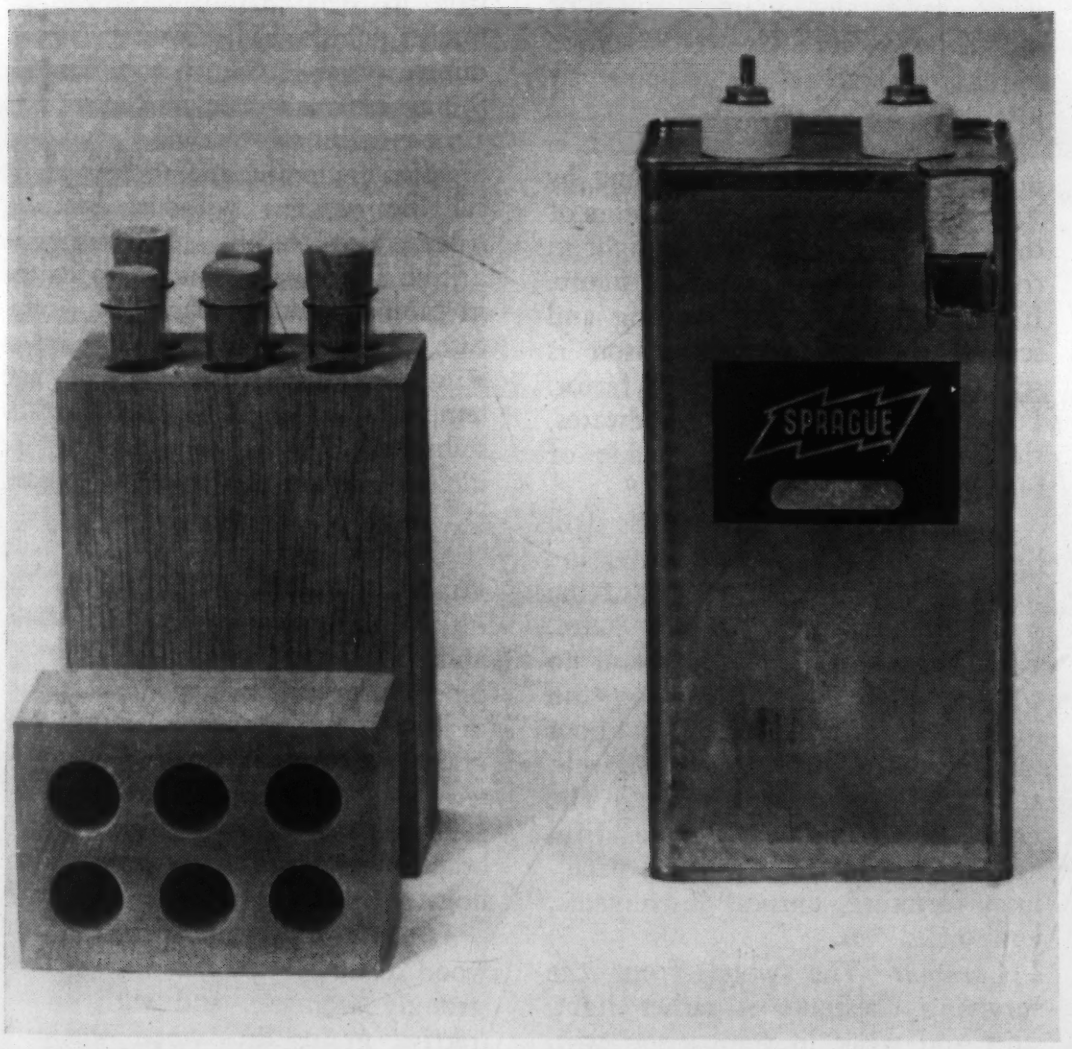
Cypress—Wood sold under this name is nearly all from the Bald Cypress. The wood is yellow in color, soft, light, and not very strong, but has high rot-resistance. This last property is the one that determines its use in most cases. It is used for cooperage, pipe and silo staves, decking and outdoor flooring, posts and ties, and marine work.

Redwood — The wood from this species is soft, light in weight, straight-grained, not strong, but is extremely rot-resistant, even when buried in the soil for hundreds of years. The heartwood is bright pink in color, and the sapwood is nearly

Laminated wood is used for the ribs of this minesweeper.



This new container stock is made up of two sheets of Kraft container board sandwiching a layer of Douglas fir veneer. Thin steel straps make for greater nail-holding ability.



Two of the great variety of uses of balsa wood: left, containers for shipping and storing glass vials; right, blocks, fillers and supports in capacitors.

white. The wood works easily and takes a good polish. Doors and other millwork, outdoor furniture, etc., use the wood.

Western Red Cedar, Port Orford Cedar, Eastern Red Cedar—Highly colored woods, these are quite rot-resistant, and contain aromatic oils that repel insects. Rot-resistance and insect repellency are the two properties for which most of the cedar wood is put to use; but the smooth, even grain of the Eastern Red Cedar makes it an ideal wood for carving. Cedar chests, insect-repellent cases, pencils are a few of its uses.

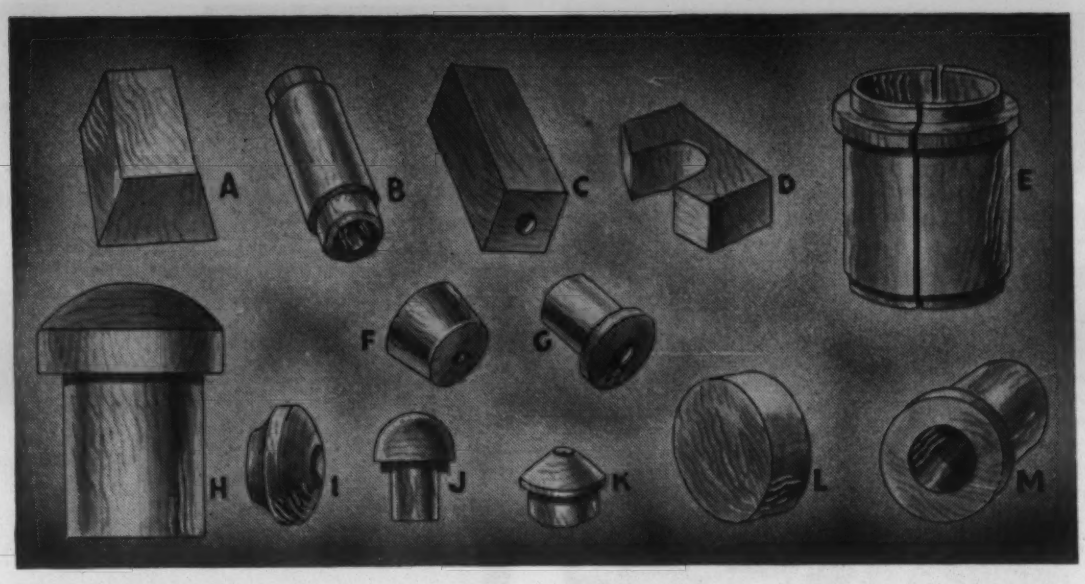
Red Fir, Balsam Fir—These trees provide a reddish, soft wood, the Red Fir being durable in contact with soil, and the Balsam Fir wood having low cost as its principal feature.

Eastern Hemlock, Western Hemlock—These woods are weak and coarse-grained, with a tendency to heartwood decay, but are low in cost and have a degree of decay-resistance in contact with soil. The wood is used for low-cost construction and millwork, boxes and crates.

The Hardwoods

Eastern White Oak, Chestnut Oak, Red Oak, Texas Red Oak, etc.—Wood is hard, heavy, strong, and durable; usually rather light in color, with dark mottlings in the heartwood, and a striking grain. The white oaks are in general preferred. Because the wood from the white oaks does not have continuous conducting elements, it is possible to make water-tight containers from it. It is used for hardwood flooring, cooperage, furniture, ship-building, posts, etc.

Sugar Maple, etc.—The wood from the maples is hard, dense, close-grained, and has the property of wearing smooth, without the development of splinters. The grain is in-



Some bearing uses of lignum vitae wood: A-stern segment bearing for propeller shaft; B, C, F, G, M-bushings; D-bearing block; E-12-in. dia split bushing; H, I, J, K-water wheel step bearing; L-thrust bearing disk.

conspicuous except in the case of such specialties as curly maple and bird's eye maple. The wood is almost white in color, and sapwood is of about the same color as heartwood. The sapwood is preferred to heartwood for hardness. It is used for flooring, furniture, boot and shoe findings, etc.

Red Gum—This wood is sometimes called Sweet Gum. It is reddish brown, often with darker streaks. Annual rings are indistinct, and the figure is generally not striking. It is softer and weaker than the preceding hardwoods, and shows a tendency to warp during and after processing. It is easily worked. The wood is frequently stained to simulate mahogany or walnut. It is much used for low-priced furniture and cabinet work, veneers, and panelling.

Hickory—Wood from these several species is among the strongest and hardest of American woods. It is almost white in color, heavy, close-grained, and with little differentiation between sapwood and heartwood. Sapwood is generally preferred to heartwood. This is the first choice wood for tool handles and the like.

Tupelo Gum—This wood, from a tree of a different genus than Red Gum, resembles that wood in many ways; but is less stable in quality. It is generally inferior. It finds use in veneer cores and panels.

Beech—The wood from this hardwood is strong, tough, extremely close-grained, hard, and difficult to split. It is reddish in color, with a thick, lighter-colored sapwood. The figure is made somewhat striking by the broad conductive elements in the wood structure. The wood possesses the feature of being almost tasteless, and so is selected for food containers and utensils. Dairy equipment and kitchen ware are examples.

Yellow Birch, Black Birch—The dense, hard, close-grained wood of the Yellow Birch closely resembles Maple in texture, and it is frequently used in imitation of that wood. The birches are also frequently used in imitation of mahogany or walnut by staining to obtain the darker colors of those woods. Birch wood is light in color, and without striking figure. It is quite resistant to denting and scratching, and for that reason is selected where abrasion is a factor. Furniture, veneers, small woodwares, shuttles and bobbins are made of birch.

Black Walnut—The rich dark brown wood of this tree brings the highest price per unit of any of the staple woods in the United States. It is tough, hard, and resistant to warping both during seasoning and in use. It can be worked without difficulty, takes glue and varnish well, and finishes to a high luster. The grain is varied, with a beautiful figure. It is used for veneers, panelling, furniture, musical instruments, gun-stocks, etc.

Chestnut—The wood from the surviving chestnuts is rather light, soft, and weak in comparison with the hardwoods used for constructional purposes. It is reddish to yellowish brown in color, and has a grain-figure that is not particularly attractive. The wood is subject to checking and warping upon drying. It is decay-resistant in contact with the soil. Veneer cores, poles and posts, low-priced furniture, and toys use this wood.

Yellow Poplar—The wood from this tree is light in color, without conspicuous grain, and one of the lightest of the American hardwoods. It is easily worked, and can be carved without difficulty. For panelling, production of excelsior, plywood, etc.

Basswood—This is a light-colored, even grained wood, soft and easily worked—for carvings, panelling, etc.

Cottonwood—The wood from these trees is soft, readily worked, even grained. It is used for production of excelsior, drawer bottoms, etc.

White Ash—A tough, durable wood with an even grain, this wood is used for airplane parts, baseball bats, snowshoes, etc.

Elm—The wood from these trees is tough, but the uneven grain makes it difficult to work. It finds application in veneer cores, panelling, etc.

Mahogany—The woods from the trees grouped together commercailly as Mahogany range in color from pale to deep reddish brown, are finely porous, with varied figure, dimensionally stable in use. Its rich beauty makes it one of the world's famous cabinet woods. It is insect repellent, and durable in service. It can be worked without difficulty, takes stains readily, and finishes to a high luster. In addition to its use in cabinet making, panelling, furniture, and fine joinery, it is used as a veneer wood, for patterns and templates that must be dimensionally stable, for aircraft propellors, for interiors of railway cars and busses, etc.

Lauaan or Tanguile—This is a group of woods coming from the Philippine and other Pacific islands, and sold as mahogany or as "Philippine mahogany". They are dark reddish in color, but have a more open grain and less attractive figure pattern than the true mahoganies. They are widely used for trim and for other purposes in imitation of mahogany.

Spanish Cedar—A reddish-brown wood related to the true mahoganies, strongly aromatic, and with an attractive grain, this wood was formerly much used as a veneer wood for cigar boxes, but is now being used to some extent in aircraft construction.

Boxwood—This is a heavy, tough wood, light in color, and with a dense grain that permits even carving. When thoroughly seasoned, it does not change dimensions readily, and so is much used for rulers and scales, slide rules, and other instru-

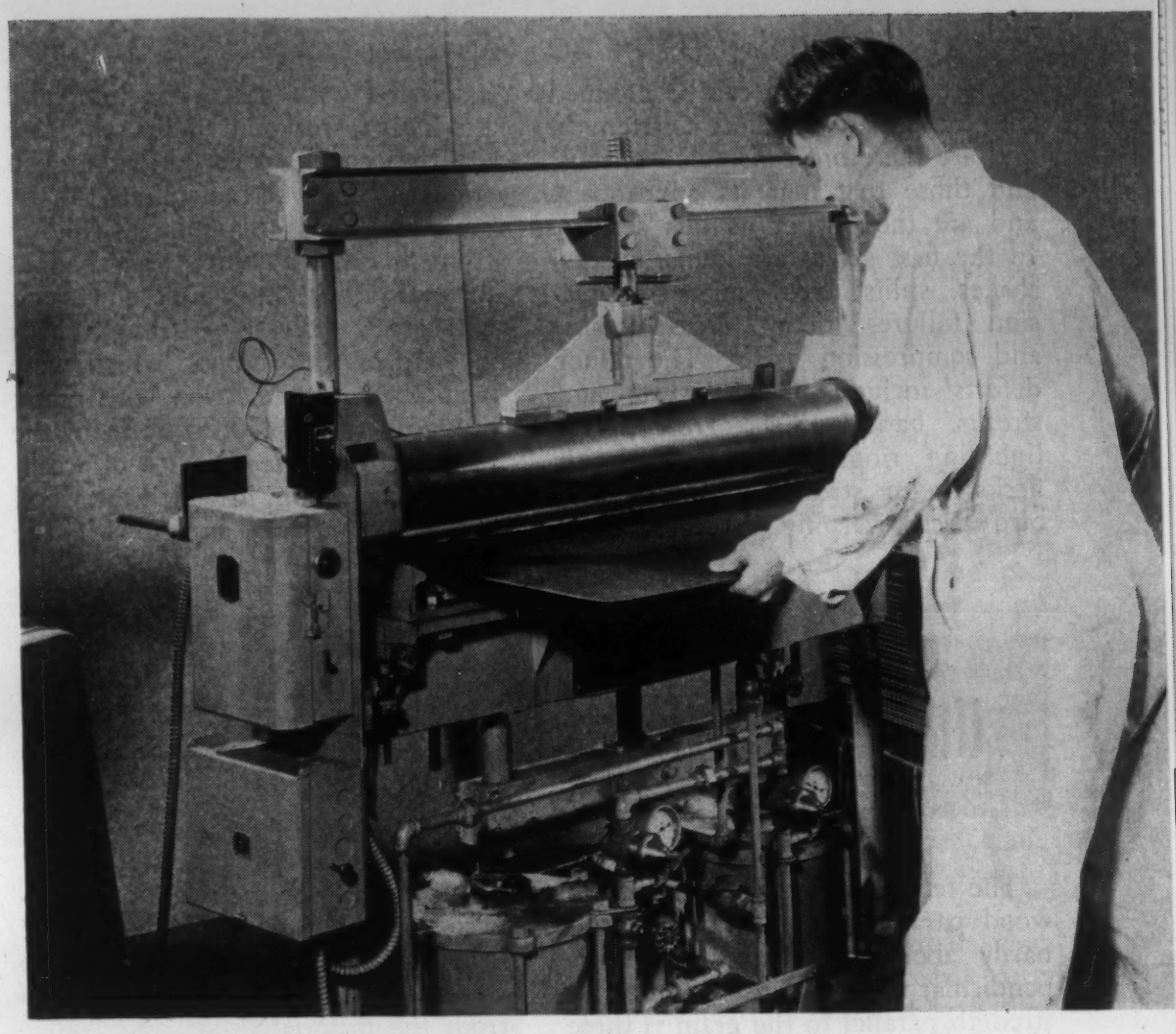
ments. It is the first choice for wood carvings. Shuttles, spools, and bobbins are frequently made of boxwood.

Rosewood—A dense, dark brown to nearly black wood with beautiful grain, oily in nature, and emitting a roselike odor, Rosewood is much used for knife handles, for scientific instruments, and occasionally for cabinetry. Its oily nature interferes with gluing.

Ebony—A hard, heavy, extremely dark heartwood, Ebony is used for inlaid work, for the black keys of pianos, knife handles, etc.

Lignum Vitae—The dense, tough, resinous dark reddish-brown heartwood of several trees of the West Indies and tropical America. It is hard and strong, and the heaviest of commercial woods. It is used for mallet heads, pulley sheaves, underwater bearings, etc. Specific gravity is about 1.3.

Balsa—One of the lightest commercial woods is the nearly white product of a South American tree, now in great demand for floats, life preservers, as a low-density core material, etc. Specific gravity is about 0.2.



Sheets of hardboard, softened by heat and water, are bent to form reflectors for fluorescent lights.

This form die using hardboard as the base and restriction plate withstand high pressures satisfactorily.

Defects in Wood

Defects in lumber can be grouped into those that will affect its strength, and are therefore considered serious, and those that mar its appearance, and are thought of as less serious. In the first group are knots, checks, shakes, splits, cross-grain, compression failures, decay, cross breaks, and compression wood. The minor defects include pitch pockets and streaks, bark pockets, frost splits, lightning rings, insect holes, pith flecks, gum streaks, black streaks, bird peck, warping, honeycombing, and burls.

Several of the strength defects are associated with grain direction, and produce a weakening effect because of the considerable difference in strength of wood parallel to the grain and across the grain. It follows from this that anything that changes the grain direction in a piece of wood will greatly affect its strength in a given direction. Knots, which were mentioned in connection with grain, produce a grain distortion in the wood that becomes an area of weakness. Cross grain, in which the wood fibers run at an angle with the axis of the piece, and diagonal grain, in which a similar condition has resulted from the sawing of the original log, are directional defects. In spiral grain, a spiral arrangement of the fibers about an axis developed as a growth condition. Checks are separations in the wood along the grain, the greater part of each extending across the annual growth rings. Checks usually occur during seasoning. Shake is a similar separation along the grain, the greater part between and parallel to the growth rings. It is usually a growth condition.

Utilizing Wood as a Material

The tensile strength of a piece of wood parallel to the grain is ordinarily about forty times that perpendicular to the grain. Compressive strength parallel to the grain is three to ten times greater than strength in compression perpendicular to the grain. In a structural member that will be subject to high stresses, it is necessary to study the relationship between direction of application of the load and the grain direction of the wood so as to obtain best results from the material.

Because the strength of wood is variable from piece to piece, and it would be extremely wasteful to design to the lowest strength values of the poorest specimens, the National Lumber Mfgrs. Assn. has worked out a system of grading for structural use. By this system each heavy timber is graded according to the species of tree, and the defects found in the piece, and a set of allowable unit stresses has been fixed for each grade. Tabulation of grades, stresses, recommended spans, etc., has been made in a handbook produced by the association, so that the user, knowing the grade of a given piece of timber, can obtain design data for it directly from the handbook. This is, of course, particularly applicable to the building construction field.

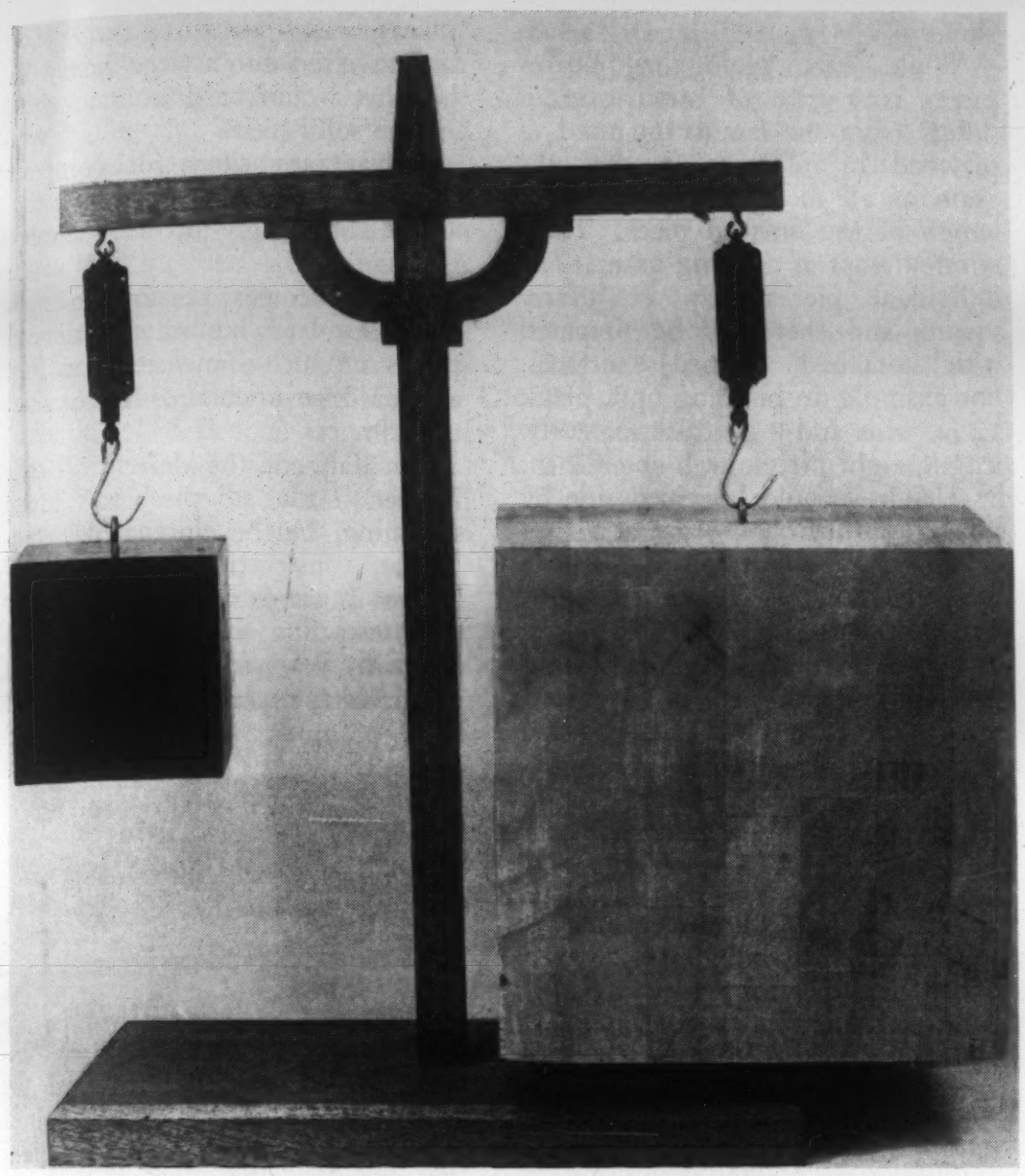
Many of the special properties of the important woods have been given in the listing of those woods. Thus, beech is tasteless in contact with foodstuffs; oak, maple, hickory, and others are hard, dense, and abrasion-resistant; cypress is rot-resistant; lignum vitae is extremely hard, heavy, and can be lubricated with water, and balsa is extremely light in weight. The uses given might suggest their suitability for other applications.

In addition to the usually considered feature of wood as a material, there are several that are important for special purposes. Radio and television cabinets made of wood will harmonize well with other furniture in the home; the fact that wood is an electrical insulator is of importance also. Wood is a poor conductor of heat, and so is comfortable to the touch, which influence its selection

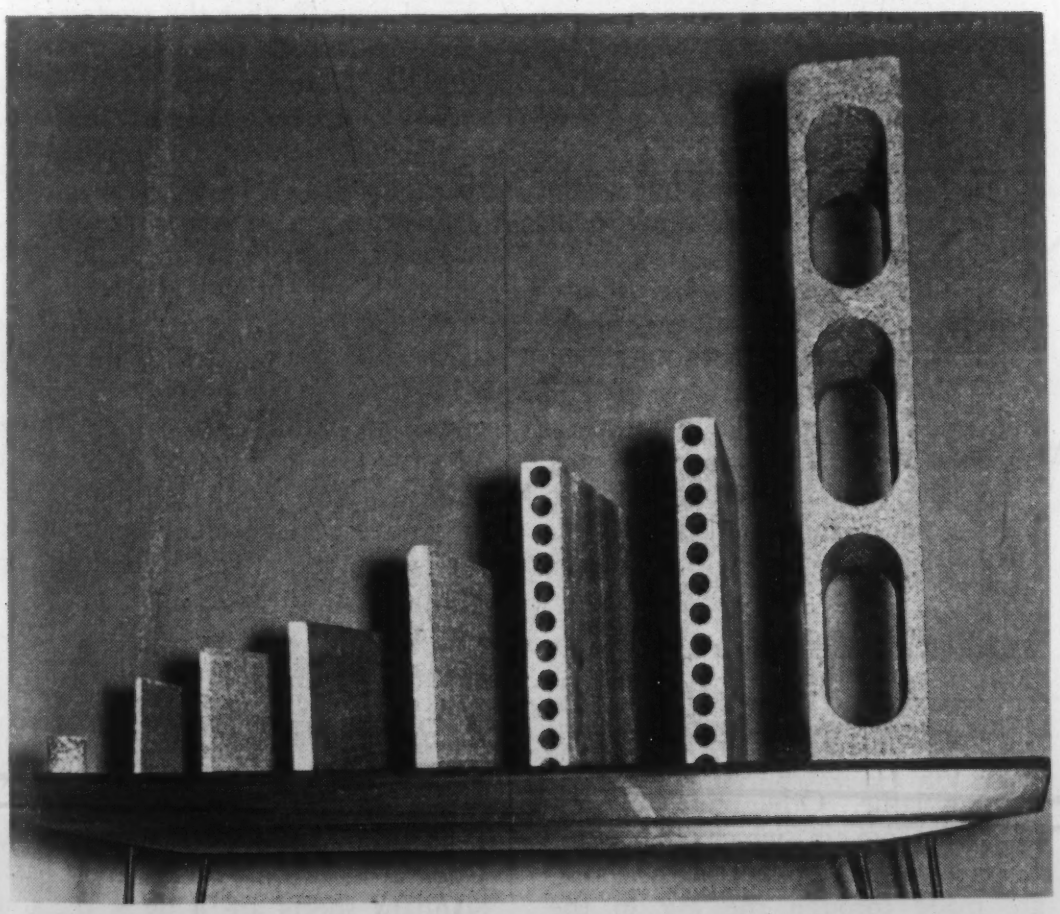
Strength of American Woods

	Sp. Gravity	Static Bending Stress at Prop. Limit, psi	Compression Max. Crushing Str. Parallel to Grain, psi	Compression Perpendicular to Grain, psi
White Ash	0.60	8,900	7,410	1,410
Basswood	0.37	5,900	4,730	450
Beech	0.64	8,700	7,300	1,250
Yellow Birch	0.62	10,100	8,170	1,190
Cottonwood, northern black	0.35	5,300	4,420	370
Elm, rock	0.63	8,000	7,050	1,520
Sweet Gum, red	0.49	8,100	5,800	860
Tupelo Gum	0.50	7,200	5,920	1,070
Hickory, bigleaf shagbark	0.69	8,900	8,000	2,220
Black Locust	0.69	12,800	10,180	2,260
Maple, Sugar	0.63	9,500	7,830	1,810
Oak, White	0.68	8,200	7,440	1,320
Oak, Red	0.63	8,400	6,920	1,260
Poplar, Yellow	0.40	6,100	5,290	580
Black Walnut	0.55	10,500	7,580	1,250
Willow, Black	0.37	3,900	3,420	480
Cedar, Port Orford	0.42	7,700	6,470	760
Cedar, Eastern Red	0.47	3,800	6,020	1,140
Cypress Southern (bald)	0.46	7,200	6,360	900
Douglas Fir (coast type)	0.48	8,100	7,420	910
Balsam Fir	0.36	5,200	4,530	380
Hemlock (eastern)	0.40	6,100	5,410	800
Hemlock (western)	0.42	6,800	6,210	680
Pine, eastern white (northern white)	0.36	6,000	4,840	550
Pine, Longleaf	0.58	9,300	8,440	1,190
Pine, Ponderosa	0.40	6,300	5,270	740
Redwood (virgin)	0.40	6,900	6,150	860
Spruce, Sitka	0.40	6,700	5,610	710

Samples were air-dried to 12% moisture content (selected from Markwardt and Wilson, U. S. Dept. of Ag., Tech. Bulletin 479, 1935)



The heaviest and lightest commercial woods in the world—balsa wood, right, and lignum-vitae, left. Both specimens weigh same.



One type of reconstituted wood consists of woodchips mixed with resin binder and pressed. Here are the types of panel that can now be produced by a new continuous process.

for many interior fittings in passenger vehicles, such as railway cars and busses.

Wood construction can be assembled by metal fastenings, or by gluing. Hide or fish glues are most used for light work, such as radio cabinets and furniture. Animal glues are easily applied, set up in a few hours with clamping, and are low in cost. They are also resoluble, and might tend to soften in conditions involving high humidity for prolonged periods. Where greater resistance to dampness is required, the casein glues are satisfactory. Resistance to deterioration during actual immersion in water, or during prolonged exposure to high humidity, can best be obtained by use of the resinous glues. Resinous glues have short pot life, require more care in application, are more costly, but are almost completely waterproof when properly applied. Resin-based glues give best resuts when cured under heat and pressure, but cold-setting types are available.

Metal fasteners include nails, wood screws, bolts, rivets, special metal plates or ferrules fastened by staking, drive screws, and several ingenious devices for special applications. Either gluing or metal fastening can be used to reinforce various shaped joints in wood, including mortising, dovetailing, matching, and rabbetting. Here the wood is cut into matching shapes, and these are fitted together to form the joint, with gluing or metal fastening to lock it.

While wood cannot be hot-formed or cold-formed in the same sense that metals can be deformed beyond their elastic limit and given a permanent shaping, wood can be bent or shaped to a considerable extent by soaking in hot water until the fibers soften, then shaping and clamping in the new shape until the wood dries. The combination of heat and moisture can be conveniently applied as wet steam, and the steam box is a standard device for forming wood. In general, the design should permit the fastening of the bent piece into other construction or into itself so that any later tendency of the wood to relax and to return to its original form will be resisted.

Compound or Composite Wood

A special type of lumber that finds application in building construction and for other purposes is what has been called "glued laminated construction", or "compound lumber".

It is lumber that has been built up of smaller pieces by bonding with resinous glue. During the period of wartime shortages it proved to be an excellent method of stretching the supply of wide planks or long timbers by creating these scarce pieces from narrow or short stock. It is continuing and increasing in use as the natural supply of large timber is reduced.

In forming compound lumber, a number of narrow pieces of wood are glued side by side (edge gluing) to form a wide plank, or several short pieces of wood may be cut into serrations at the ends, and the ends matched and glued together (end gluing) to form a long piece of wood. The two processes can be combined. Common practice in structural members is a scarb with a 12 to 1 slope.

While edge gluing of narrow pieces is a type of laminating, it differs from the laminating used in plywood manufacture in that the grain of all members is parallel to length of the finished piece. There is no attempt at crossing grain. The individual pieces may be nearly square, and they will be prepared with smoothed (planed) surfaces. For example, in building up a plank 12 in. wide and 2 in. thick, of 20-ft. length, eight pieces, each about 2 in. by 1½ in., would be glued side by side. It is not necessary that all be of the same width, so that any pieces available can be joined. Lengths can be made up by end gluing several or all of the members, using care to keep the end joints scattered throughout the plank. By this means waste pieces of lumber can be converted into a large, heavy timber that would be difficult to obtain in one solid piece.

Advantages cited for composite lumber are:

1) The supply of large timbers is augmented.

2) It becomes possible to make from standard lumber a variety of pieces of such dimensions or form as would be unobtainable from natural timber.

3) Many of the defects of solid lumber, such as checking during seasoning, can be eliminated.

The construction of compound lumber is an extension of the practice of scarfing, which has been used for many years for the same reasons given for the use of compound lumber.

Laminated Wood

The considerable difference in the strength of wood parallel to the grain and perpendicular to the grain leads to the obvious device of crossing the grains of two or more pieces of wood so as to equalize the strength. Development of adhesives made possible the building of wood pieces in multiple layers, and these layers can be crossed. While veneering and inlaying of wood has been done for many centuries, and plywood antedates the discovery of modern waterproof adhesives, the use of these adhesives, first with a degree of water resistance, then of the resinous glues with almost complete waterproofness, made laminated wood an important and versatile material. Waterproof phenolic adhesives and water resistant urea adhesives have largely supplanted other types in plywood manufacture, except that soybean and blood glues are sometimes used in making water resistant softwood plywood.

The resulting laminate is not stronger than the parallel-to-grain strength of the original wood, but the better balance of parallel and cross-grain strength make it superior for many purposes. Great rigidity is obtained by distribution of stresses over a wider area.

In addition to the matter of equalizing strength in several directions, the laminating of wood offers the following advantages:

1) The material can be produced in large sheets otherwise unobtainable in a single piece.

2) The material possesses greater stability to moisture, as the swelling and shrinkage of wood is greatest across the grain.

3) A facing of expensive wood can be used over lower-cost inner layers.

4) Thin sheets that would split in solid wood can be prepared and used successfully as laminates.

5) Pieces with minor defects can be utilized by careful patching, or in inner layers.

6) Lower-density woods or low-density materials can be used for the cores to obtain a composite material.

7) Combinations of wood and non-wood are possible, with metal or plastics, for facing or for cores.

8) Laminations can be laid up over a form and bonded into the finished shape in a single operation.

Sizes and Grades

The thin sheets of wood that make the plies are frequently rotary-cut from the log on a machine resembling a lathe. Other cuts, and especially those in which the wood offers a beautiful figure in the grain, are made through the log in the same manner as planks would be sawed from it except that cuts are made by slicing with a huge knife. In the case of the softwoods, the plies are standard thicknesses, and these are 1/10 in., ⅛ in., and 1/6 in. Face plies for hardwood panels are usually 1/28 in., 1/24 in., and 1/20 in.

A fundamental difference between the softwood laminates and the hardwood types is that the western softwood plywoods are used for structural applications and for concealed utility purposes, and the hardwood plywoods are used for exposed surfaces to be given a natural or a stained finish. The softwood plywoods are usually of the same wood through and through, but the hardwood plywoods are ordinarily made with inner plies of lower-cost woods. These might be basswood, poplar, gum, sycamore, etc. These inner plies may or may not be of the same thickness as the surface plies. The two faces will normally be balanced —that is, they will ordinarily be of the same thickness.

Hardwood plywoods using gum, poplar, or magnolia are much used as utility materials, frequently with a facing of plastics or other special material, for instrument or equipment cases, and for packing cases.

Softwood plywoods are made with Douglas fir or pine for the most part. Standard sheets are 4 by 8 ft., and from ¼ to 1⅝ in. thick. Sheets from ¼ to ⅜ in. are usually three-ply, and ½ and ¾ in. sheets are

five-ply. White pine is made up in substantial quantity in thicknesses to 2 in., and these thick sheets are usually nine-ply. The thick sheets are much used by pattern-makers.

Hardwood plywoods are made in sheets from about 1/8 to about 1 3/16 in. in thickness and special cut sizes are more generally available than in the case of softwood plywoods. Sheets of hardwood plywood 0.070 in. in thickness are being made for the covering of helicopter blades, and stock 1 3/8 to 1 3/4 in. in thickness is made in quantity for flush doors, and stock 5 in. thick is used for certain helicopter blades.

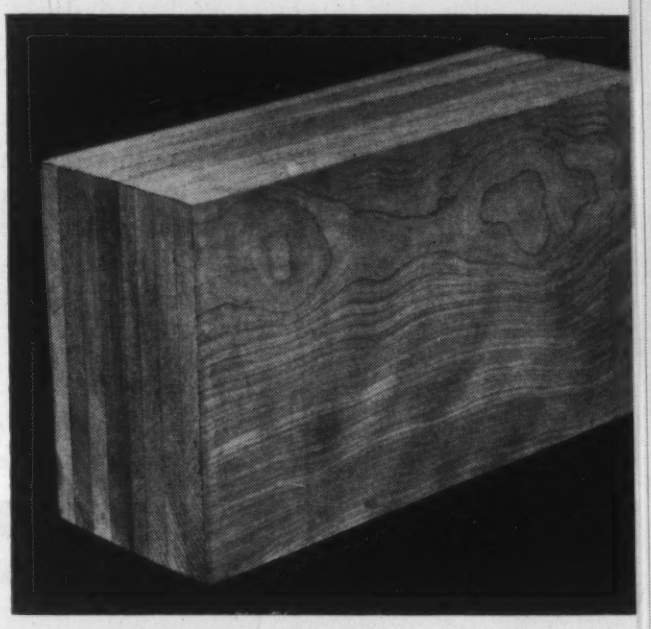
The grading of plywood is done according to specifications adopted by the trade associations, and are available in government publications. Publication CS 45-48 gives the grades for fir plywood; Publication CS 157-49 gives those for pine plywood, and the specifications for hardwood plywoods, except for certain specialty types, are set down in Publication CS 35-49.

Practically, there are four grades established for each type of plywood as given above. For fir plywood, these are given as A.B.C. and D. The grades are decided upon the basis of utility. Grade A is intended to provide a smooth paintable surface; some tightly patched defects are permitted. These are such as contain oblong patches glued in place and sanded so that the patch will not loosen or show a glue-line through the paint. For B grade surfaces, some tight minor defects are permitted, such as circular patched defects. Grade C permits some small open defects, and Grade D permits open defects, splits at the end of the panel, etc. The specifications for pine plywood are differently stated, but sum up to about the same utility. They are described as Sound, 1 side, or Sound, 2 sides, to indicate that only oblong tight patches are used in repairs on the surfaces referred to, or as Solid, 1 side, etc., to indicate that circular patches have been used. The lower grades will show some open defects.

Hardwood panels are graded according to four grades, indicated as 1, 2, 3, and 4. Grade No. 1 is intended for a paint finish; No. 3 is for utility panels for such uses as drawer bottoms, and No. 4 is for backs of cases and similar purposes.

The type of adhesive used determines the moisture resistance of the plywood. The following is a guide:
Phenol-formaldehyde adhesives. Completely waterproof. Suitable for use in boats, building exteriors, etc.
Resorcinol-formaldehyde adhesives. Completely waterproof. Suitable for marine and exterior use.
Urea adhesives. Cold-waterproof. Suitable for ordinary conditions, or for immersion to at least 13 cycles.
Casein adhesives. Cold-waterproof. Suitable for conditions, or for immersion to at least 2 cycles.
Soybean adhesives. Cold-waterproof. Suitable for ordinary conditions, or for immersion to at least 2 cycles.
Blood adhesives. Cold-waterproof. Suitable for conditions, or for immersion to at least 10 cycles.
Hide glues. Resoluble; dry bond. Suitable for ordinary interior use.

While the chief uses of plywood, as with lumber, are in the furniture and building fields, it also goes into the production of many industrial items. Seats, flooring, wall paneling, and fittings in busses, trucks, planes and railway cars make use of plywood. Concrete forms are now made with the laminate. Patterns, templates, and profile guides sometimes use plywood. Plywood boxcars have been tried on railroads and found serviceable, especially for shipments of grain and similar bulk commodities. Plywood boats and aircraft are being made commercially. Radio and television cabinets and speaker baffles have already been mentioned as plywood applications; housings and cabinets for many kinds of instruments and equipment are made of the same material.



Birch lumber laminate from which third rail shoe beams are machined. One-half in. birch layers are glued together with phenolic resin adhesive.

Modified Woods

There are several processes in commercial use by which wood is treated to obtain certain desirable physical properties without changing the basic structure of the wood. In one of these the wood is impregnated with resins which are then polymerized to give the wood new properties. In another it is impregnated with resins and compressed with heat so that the resins are set and the compressed structure stabilized.

Because thin sections are easier to impregnate with resins than thicker sections, these modifications are usually performed with veneers or with plywood. The resin used are phenol-formaldehyde or furfural-formaldehyde, and they are applied in the uncured state ("A" stage resin) as a water solution. The resin can be applied by soaking the wood or veneer for a long time, perhaps several days, in the solution, or it can be applied more quickly in a pressure vessel under an air pressure of about 100 psi. Pressure treating might require from 15 min. to several hours. When complete and uniform impregnation is not required, solution is applied to the veneer by a spreader, or by compressing wood between rolls to expel air and feeding it directly into a resin solution.

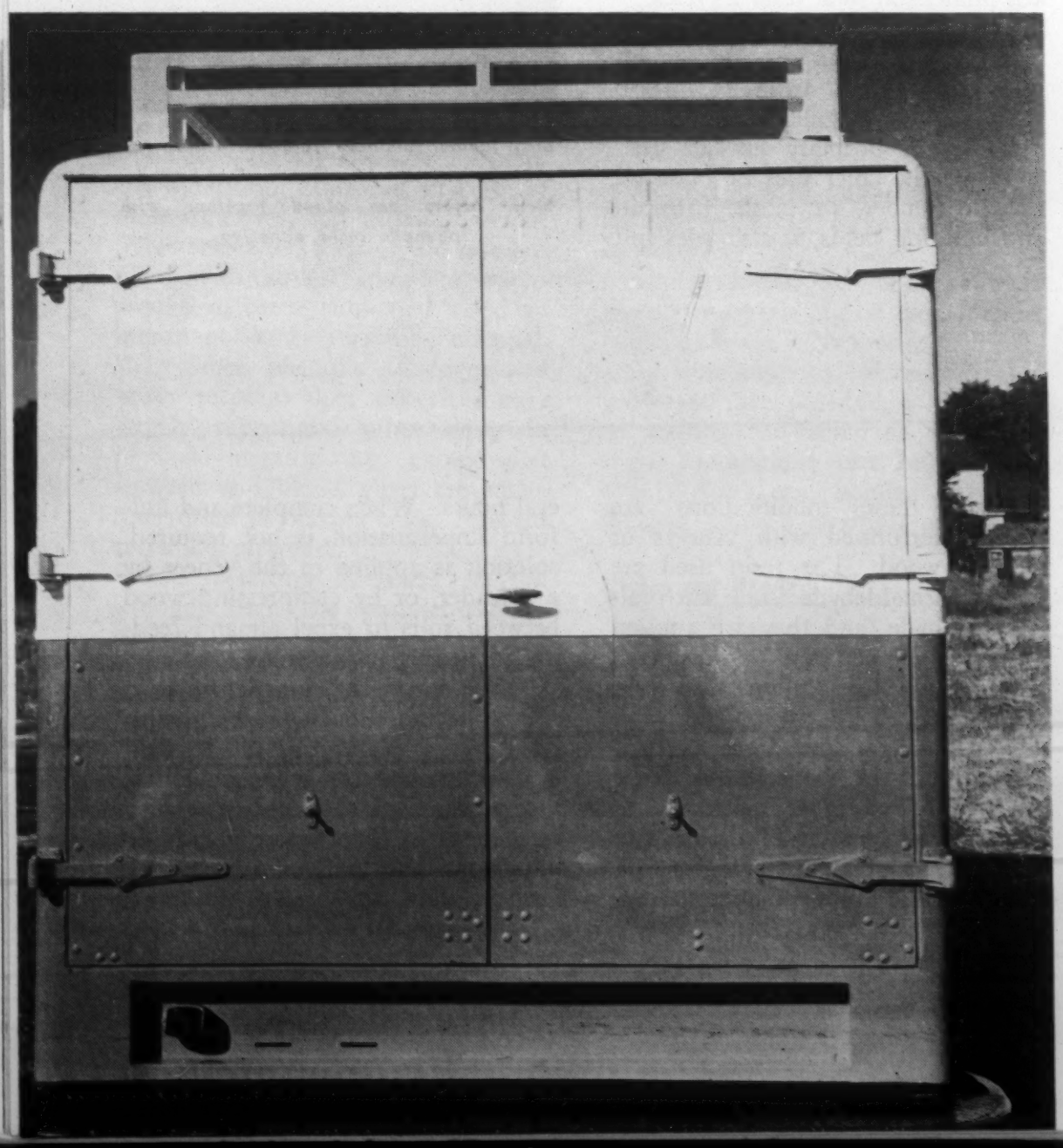
When wood is being densified as a part of the process, soaking with resin has a plasticizing effect, and permits compressing with about half the pressure than would otherwise be necessary. The wood is usually impregnated with its own weight of resin solution.

If the resin is to be evenly distributed through the wood, a diffusing operation follows impregnation. The wood is then dried at a temperature below that required to cure the resin, until the moisture content is reduced to less than 6%. Drying for about 16 hr at a temperature not above 130 F will usually suffice. The resin is then cured by heating the piece at 200 F for about 24 hr, or at 300 F for about ½ hr.

Three different modifications of wood can be produced through use of some or all of these processes. First, wood can be densified by compressing it to smaller volume. This can be done with solid wood or with plywood, and the product is called *densified wood,* or *superpressed plywood.* Pressure in the order of 250 psi will reduce the volume of the wood by 1/3 to ½, and the specific gravity will be increased to about 0.7 to 1.0. Compressed wood tends to absorb moisture and to expand, so that the densification is lost. For this reason densification is used in connection with resin impregnation, and the resultant material is called *compregnated wood,* or *compreg.* The amount of resin added will be from about 10 to 30% of the weight of dry wood, and specific gravity will be from about 1.30 to 1.35. The higher resin content is desirable when dimensional stability is the property required, while 10 to 20% resin, not diffused, will provide a wear-resistant surface. The strength of the impregnated wood is about the same as that of the wood itself; the resin adds little to it. If the wood or plywood is impregnated with resin without densifying, it is called *impreg.* Specific gravity, due to the absorption of resin, is about 20% higher than that of the untreated wood.

Airplane wing parts being removed after forming and blanking operations on hardboard die stock at Chance-Vought plant.

The doors of Montpelier truck bodies are made of ⅜-in. plywood covered with 20-gage zincbond.



The properties developed in these modified woods are:

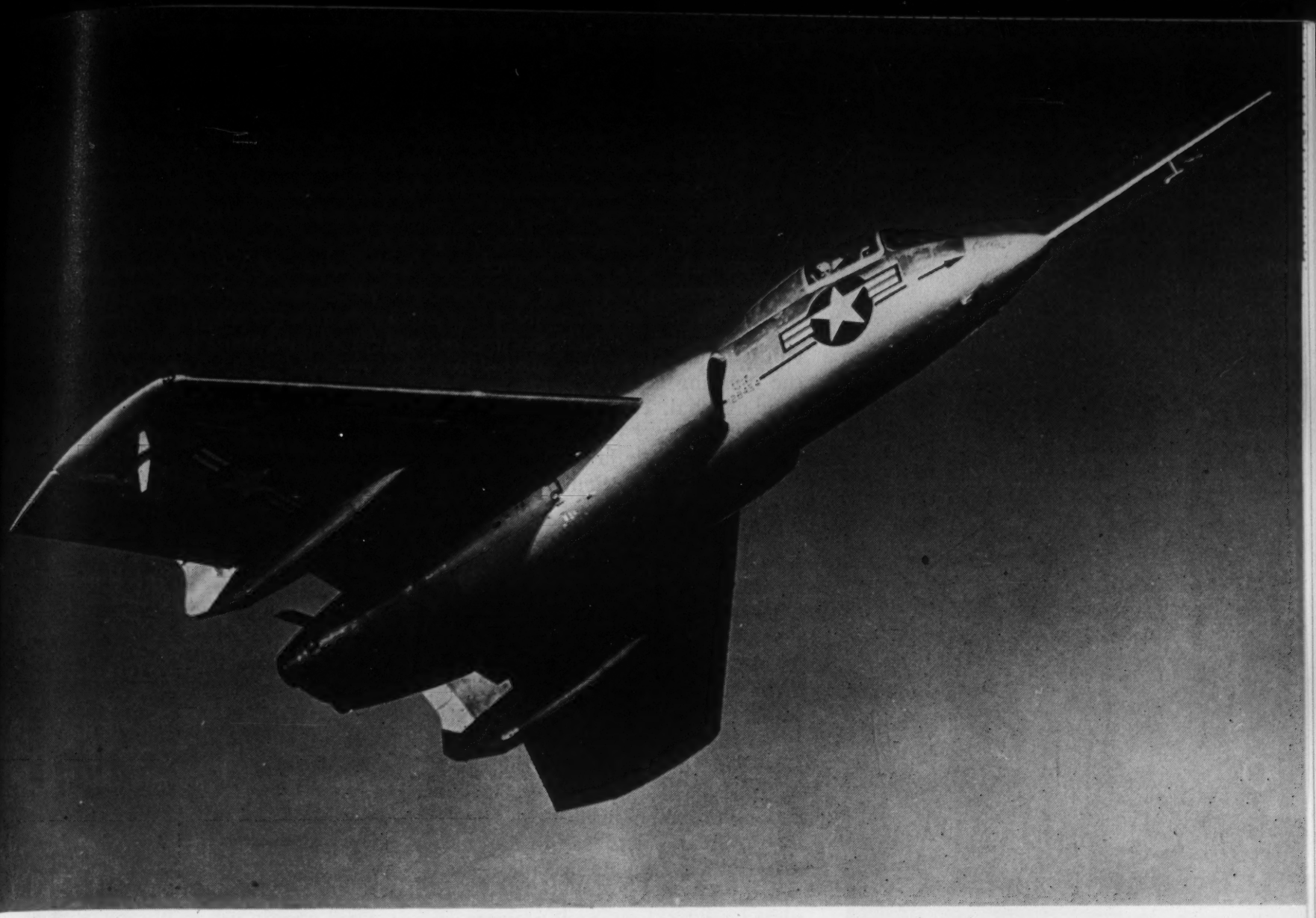
1) Reduced absorption of moisture. This property results in greater dimensional stability, less tendency for the grain to raise, less tendency toward surface checking, improved electrical resistance, and resistance to decay.

2) Improved abrasion resistance.

3) Improved chemical resistance.

4) For compregnated wood, hardness might be 10 to 20 times that of unprocessed wood.

5) Toughness, oddly enough, decreases for both impreg and compreg



This "Cutlass" jet fighter contains balsa wood as part of its skin in sandwich construction.

as the resin content increases.

6) Compreg is better than impreg in moisture resistance and flame resistance.

When impregnated veneers are used for compregnated wood, additional resin is not required for the bonding into the finished piece unless resin content is below 30%, or the veneers are to be cross-bonded. The bonded plies can be machined to finished form, though machining is difficult as with all resinous materials.

Most woods can be compregnated or impregnated; woods that contain large amounts of natural resin are the exception.

A variation of this process of wood modification is the molding of impregnated wood chips or blocks. Wood that has been impregnated with resin and dried without curing the resin is cut into chips or blocks, phenolic adhesive is added, and the mixture is formed into a preform at a temperature of about 200 F at about 150 psi for a short time. The resins are only partially cured. When placed in a mold cavity and heated to approximately 300 F under pressure, the cure is completed.

Impregnated and compregnated wood is used in propellers for aircraft, for knife handles, gears and pulleys, fan blades, shuttles and bobbins for looms, and dies for forming light metals.

A method for treating wood that provides even greater moisture resistance is acetylation. This is still in the developmental stage. It consists of exposing dried veneers to the vapors of acetic anhydride, with pyridine as a catalyst, in a closed vessel at temperatures ranging from 180 to 240 F. The wood is chemically modified by this process, though the basic structure remains. Specific gravity is increased by about 10%, the color of the wood is little changed, and moisture transmission is only about 20% of that of untreated wood. Strength seems to be slightly improved by the process.

Reconstituted Woods

Another method of eliminating the orientation of wood, with its strongly directional properties, is to destroy the basic structure of the wood, and to reconstitute the wood material in an unoriented condition. This is the basis of a class of materials, mostly sheet stock, some of them well established, others quite new. The basic structure can be destroyed by breaking up the wood with steam pressure to obtain a mass of fiber, which is afterward reconstituted in unoriented fashion. Another method of destroying the basic structure is to cut the wood into chips or other small particles, and afterward reuniting the chips in random fashion with a binder.

Some of the features of reconstituted woods are:

1) It is possible to use wood wastes or woods of low value in production of the reconstituted ma-

Plain and asphalt teakwood used as container material by Republic Aviation Corp.

terial.

2) Thin sheets can be made that will have less danger of splitting than solid wood of the same dimensions.

3) The sheets can be produced in large areas impossible to obtain in solid wood.

4) In some processes, it is possible to apply a metallic or nonmetallic facing at the time of manufacture.

One of the oldest and best known types of reconstituted woods is a material in which the wood, cut into chips, is disintegrated by steam and the resulting fiber is reformed into a solid material. The fibers are obtained in this process include both the cellulose, or basic fibrous material of the wood, and the lignin, or cementing material. In one process the lignin serves as the cementing material in the reconstituted wood, as it did in the original material. In other processes a binder, usually a phenolic resin, is added. Chips can usually be prepared from small trees or branches, or from blocks of waste wood from woodworking plants.

When the lignin itself is used as a binder, the fibers from the disintegrated wood are run over a papermaking machine to mat the fibers, then over drying rolls, and the dried mat is then cut into rectangles and stored. The rectangles are next compacted under heat and pressure in large platen presses to the dgeree of hardness and density desired. When a resinous binder is added, the rectangles are similarly pressed at the temperature and for the time required to cure the resin.

Other reconstituted woods make use of chips, planer shavings, or even sawdust, and mix this woody material with a resinous binder to form the board. Chips from block ends are used in making a board, and cooked chips, reduced to fiber in an attrition mill, form the basis for another. Waste veneer scraps, shredded, mixed with a binder, and made into a board, are used for chair backs and seats. Aspen, of little value commercially, is shredded and mixed with a resin binder to form another reconstituted wood sheet.

A product that differs in composition from the reconstituted woods, but is usually classified with them because it is produced and sold by a supplier of reconstituted woods, is a die material made by compacting resin-bonded veneers. The material is compacted under high pressure to only a few percent of voids, and approaches the ultimate density of wood substance. Specific gravity is about 1.3. When coated with a special surfacing resin the material gives good results for forming dies for pressing or stretching light metals, chucks for spinning, router templates, and for jigs and fixture. Hardboard die materials have several advantages over metal dies for the forming of light-gage metals, weigh about one-sixth as much as steel; provide greater ease of machining, originally and for alternations; have good coefficient of friction, and good dimensional stability.

A machine for continuously producing reconstituted wood from chips, now in use in Europe, is being experimentally studied in this country. The machine, the Bartrev press, uses chips moistened with a resin binder which are blown onto a belt of stainless steel, conveyed between several platens, and comes out a continuous web. The material can be coiled, or cut to length with a moving saw. Laminating on the machine is possible by using a wood ply above or below the chip mass, or both above and below. Metal or printed paper can be similarly used.

Reconstituted woods are used for vehicle seats and backs, drawer bottoms, display panels, for instrument packing in the case of soft grades, for concealed or painted surfaces in general.

Wood Pulp and Paper

A class of fibrous products is developed from wood fibers by chemically treating the wood to dissolve the cementing lignin, and utilizing the cellulose fiber so obtained. When used as a fibrous mass, with or without bleaching and further treatment, the material is called *wood pulp*. If the fiber is further processed, then formed into a thin sheet of interlocked fibers, the material is called *paper* or *fiberboard*.

There are several processes for dissolving the lignin in wood, the important difference being in the chemical used. If the chemical is caustic soda, the resulting fiber is called soda pulp. Use of a solution of calcium bisulphite produces sulphite pulp, and use of a mixture of alkaline sulphides produces sulphate, or kraft, pulp. The soda process is used primarily for certain hardwoods, while the sulphite and kraft processes use the softwoods.

Two other processes produce pulps important in the arts, but not much used in the fabrication of industrial products. These are the groundwood processes by which softwood logs are

ground mechanically against a large wheel, and the semi-chemical process, in which logs are cooked with a little chemical or with hot water, and then ground or otherwise pulped. In neither case is the cementing lignin dissolved. Ground pulp tends to yellow and weaken in a short time. Semi-chemical pulp is stronger and more lasting. While large quantities of groundwood pulp are made for the production of newsprint, its only uses of interest to the materials engineer are as a material for low-cost wrapping paper, or for paper backing for foil or other thin sheet material. Semi-chemical pulp goes into container board.

Wood Pulp

Wood pulp is used industrially as a fibrous reinforcing matering in plastics, as a source of cellulose for further processing, as a cushioning material in packaging and similar applications, etc. When used as a reinforcing material for plastics, the material used is usually sulphite pulp or kraft pulp, both of which are longer-fibered than the soda pulp made from hardwoods. The kraft fiber is the strongest of the wood fibers produced by these primary chemical means. It has the feature, objectionable for some applications, of being brownish in color. Bleaching lightens the color, but also lowers the strength. When purchased for an application in which strength is the primary requirement, and color is unimportant, the unbleached kraft pulp might be the most satisfactory. Semi-bleached and bleached kraft pulps are also produced.

Sulfite pulps can be produced by either of two well-recognized methods, one producing a stronger pulp, but difficult to bleach, the other producing an easy bleaching but weaker pulp. The former, called Mitscherlich pulp, is usually specified when the fiber is to be used as a reinforcement in plastics.

A special type of wood pulp, produced by treating the pulp with chemicals to dissolve out the unwanted cellulosics, is alpha cellulose. This is the only successful filler for urea-formaldehyde plastics, and is successful for use with the melamine-formaldehydes also. It has the property of being compatible with the urea-formaldehyde resins, which seem to require a degree of hygroscopicity in the filler, and its white color lends it to production of white molded pieces, or to colored parts by addition of dyes.

The alpha celluloses are also called dissolving pulps, because they can be chemically dissolved, then reprecipitated to produce cellophane, rayons, nitrocellulose, etc.

Wood pulps go into mixtures for welding rod coatings; are used as a filler in rubber to obtain a clearer molding; as the fibrous constituent in a leatherlike composition for shoe insoles, handbags, etc.; as a filter medium, and as a chemical ingredient in detergents.

Papers for Industry

When fibrous materials are suspended in water as a thin slurry, the slurry run onto a wire screen or felt blanket that permits the water to drain off, and the resulting thin layer of fibers then removed and dried, the material obtained is called paper or paperboard. Thin sheets, only a few thousandths of an inch thick, are called paper, and the heavier layers are called paperboard or fiberboard. While many materials, such as cotton, linen, asbestos, and glass, can be made into paper by the process, only those produced from wood pulp are here included.

Huge quantities of paper and paperboard go into the wrapping and packaging of industrial products. Much of this is made from kraft pulp, and is used in the unbleached condition. Most papers, however, are made from mixtures of pulps. For the cheapest fiberboards repulped papers can be used with little refining or bleaching, and the off-color covered with a dye or pigment. Container boards for food products, however, must meet requirements of the U. S. Dept. of Agriculture.

Paper is a reasonably good dielectric, and large quantities of it are used between the plates in small electrical condensers. Because the material is hygroscopic, the assembled condenser may be impregnated with wax to retain original values.

The porous nature of paper is used to advantage in the production of water-resistant containers and wrapping papers. A layer of asphaltum is applied to one surface of the paper, and another paper is placed over it, the water-resistant material becoming an invisible interlayer. Other water-resistant papers are made by adding resin in the uncured, water-soluble stage to the slurry during the papermaking process. Melamine-formaldehydes are most used for this purpose, and the product is used for water-resistant paper bags, military maps, etc.

Water-resistant papers are also made by adding wax or rosin emulsions to the slurry during manufacture, or by coating or impregnating the finished paper with wax. Chlorinated waxes are sometimes used for this latter purpose, and the material so produced finds use as a waterproof wrapping for electrical conductors, as a dielectric, etc.

Papers for use as the base for coated abrasives, for tapes, etc., are coated with an adhesive. For the tapes, the adhesive may be of the pressure-sensitive type, and such tapes are much used for masking during spray painting, or for other temporary protection.

A pipe made of paper, wound into a multi-layered spiral and heavily impregnated with pitch, is finding application for underground piping in cities, for conduit in buildings, and the like. It is claimed that the paper pipe retains a degree of resiliency and so is better able to withstand traffic vibration.

Paper, usually mascerated, is used as a reinforcing filler for plastics. It greatly increases the strength and impact resistance without reducing moldability drastically.

This refined wood cellulose in powder form resembles appearance of flour. It is used by industry as an ingredient in many different materials.

An interesting derivative of cotton paperboard is vulcanized fiber, produced by treating the board with a chemical solution, usually zinc chloride. The fiberboard is made water-resistant, much tougher and stiffer, and with good abrasion resistance. Its combination of good electrical properties and resistance to charring fit it for use as the casing for electrical cartridge-type fuses. It goes into gaskets, aircraft parts, disks for coasted abrasives, tote boxes, gears, etc.

Paper is one of the important laminating materials for thermosetting plastics. The National Electrical Manufacturers' Association lists six grades of paper laminates, three intended primarily for best electrical properties, and three for good electrical properties combined with good punching. Good punching properties are obtained by slightly plasticizing the resin, and are not determined by the paper used in laminating.

Laminating with paper as the reinforcing material is accomplished by impregnating the paper with the resin in the uncured, water-soluble stage. The saturated papers are then laid up in piles if for flat stock, or wound around mandrels if for rod or tube, and the cure is completed in a mold under high pressure.

Paper is also impregnated with rubber, applied in solution or as a latex, for the production of water-proof film materials. Printed paper coated with rubber is used for low-cost window shades, aprons, etc.

An interesting use for printed paper is the floor covering now being sold for home and institutional use. This is made by coating a layer of heavy paper, upon which colored designs are printed, with a heavy film of vinyl plastic. The design shows through the nearly colorless plastic covering. When the paper is backed with a layer of felt or burlap, bonded to the paper with an asphalt layer, it forms a durable, low-cost floor covering.

Printed paper is also coated with vinyl plastics to produce a window shade.

Wood Products-Cork

Aside from wood itself, trees produce many industrial materials. Rubber, rosin, turpentine, many medicinals, stem or fruit fibers, tanning materials, and wood distillation products are forest products rather than products of wood itself, but one—cork—is truly wood.

Cork is obtained from the bark of the Cork Oak, growing commercially in the Mediterranean region, and particularly in Spain and Portugal. The trees can be stripped once each eight to ten years. After removal from the tree, the cork is air-seasoned, then boiled to remove the tannins and soften the outer layers. The rough outer portions are then scraped off; the remainder is flattened, dried, trimmed, and graded. The coarse material is ground, to be used in cork composition products.

The properties that make cork a useful industrial material are:

1) Light weight and bouyancy.
2) Resilience and compressibility.
3) Resistance to moisture and common liquids.
4) Good heat insulating value.
5) Good sound and vibration insulation.
6) High coefficient of friction.

In the structure of cork, about half of the volume is air space. The most characteristic compound is a flexible, moisture-proof substance called suberin. The cork material is extremely resilient, and does not easily take a permanent set. A cork stopper held tightly in a bottle for years will quickly return to a shape close to the original. The material acts as its own adhesive when ground cork is heated and pressed together to produce cork composition; a binder is usually added to reinforce it.

The uses of cork date back to Roman times, when the material was used as a bottle stopper. Considerable quantities are still used for this purpose. Linoleum, made with oxidized linseed oil and ground cork on a burlap backing, uses a large amount of cork waste, or ground cork. Its water-resistance and buoyancy are utilized in life preservers. Its low rate of heat conduction fit it for use as handles of cookware and the like, while its flexibility and high coefficient of friction are put to use in handles for such items as fishing rods. Cork insulation, which now has many competitors, is still used for refrigerators, refrigerator cars, and piping. Base blocks for isolation of vibration, and acoustical tile use its vibration-absorbing qualities.

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Materials Data Sheet

Carbon and Graphite Parts

Depending on their method of production, these materials can have widely varying properties. Representative ranges of typical materials are given. Among applications are mechanical parts, chemical equipment, refractory liners, brushes for electrical machines, contact and heating elements.

Typical Properties

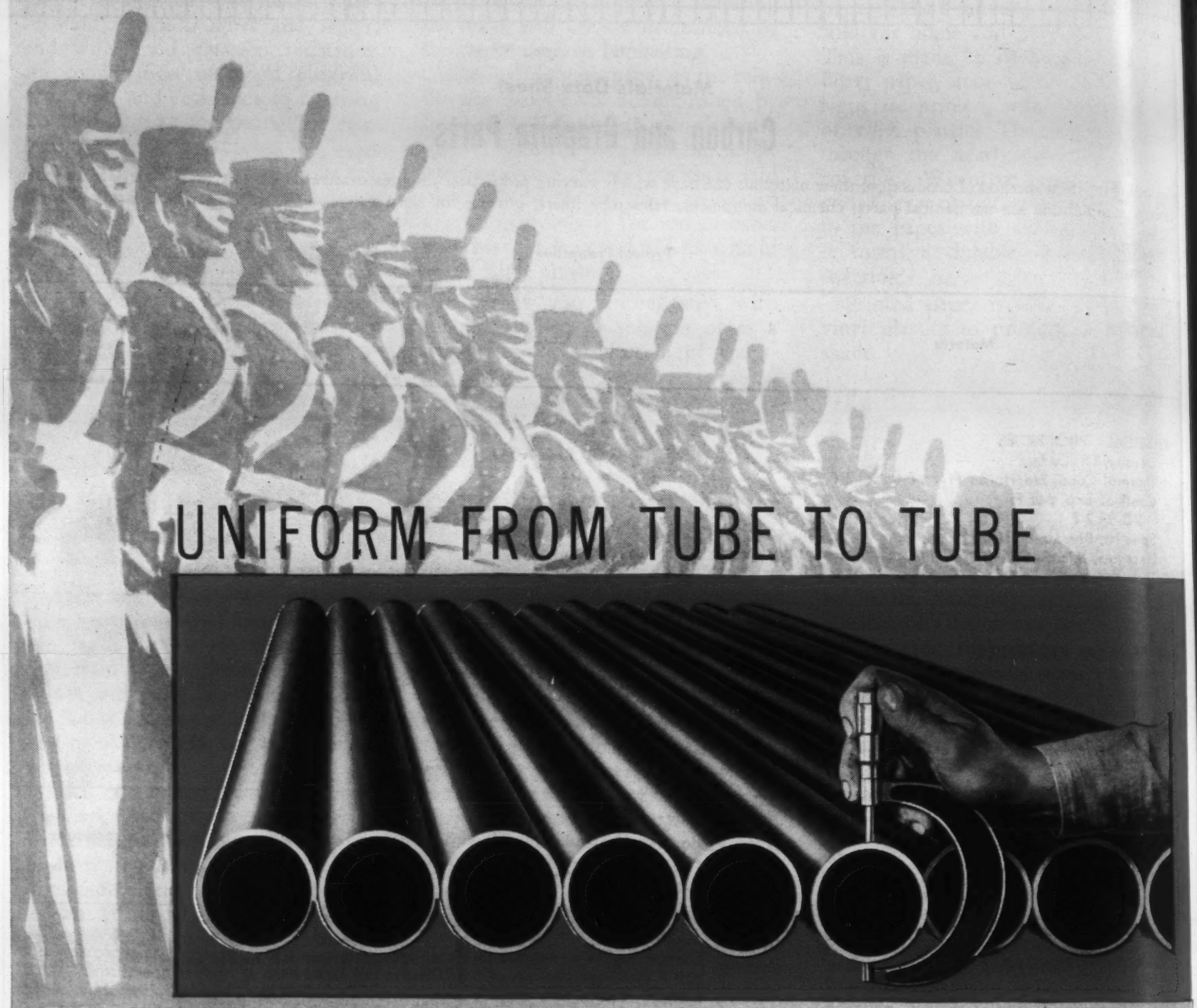
Materia	Carbon	Graphite
PHYSICAL PROPERTIES		
Density, Lb/Cu In.	0.054–0.059	0.054–0.059
Thermal Cond, Btu/Hr/Sq Ft/Ft/F @ 212 F	3–5	70–86
Coeff of Exp, per F:		
70-212 F	$1.3–1.5 \times 10^{-6}$	$1.0–1.3 \times 10^{-6}$
Spec Ht, Btu/Lb/F (100 F)	0.18	0.18
Elect Res, Microhm-Cm @ 68 F	3500–4600	800–1300
MECHANICAL PROPERTIES		
Mod of Elasticity in Tension, Psi	$1.6–1.9 \times 10^{6}$	$0.8–1.4 \times 10^{6}$
Tensile Str, Psi[1]	900–1100	440–2000[2]
Compressive Str, Psi[1]	6300–9000	1700–7500[2]
Flexural Str, Psi[1]	2500–3000	800–4000[2]
Hardness, Scleroscope (Shore)	60–90	20–45
FABRICATING METHODS	Powdered material mixed with binder and shaped by molding under pressure or extrusion. Green parts baked at above 1800 F.	
CORROSION RESISTANCE	Carbon begins to oxidize in air at approximately 630 F, graphite at approximately 810 F although the rate of oxidation is not rapid even at high temperatures. With a steam or a carbon dioxide atmosphere, the temperature can be raised above a red heat before excessive oxidation occurs. Alkalies in solution do not attack these materials but fused hydroxides and carbonates attack them at high temperatures. They are not attacked by dilute acids including hydrofluoric but strongly oxidizing chemicals will attack both carbon and graphite.	
USES	Mechanical; sealing rings, pump and valve parts, bearing, pistons and piston rings. Electrical; battery carbons, contacts, welding carbons, anodes, brushes for electrical machines. Refractory; linings, molds, continuous casting dies, furnace boats. Chemical: complete line of corrosion resistant equipment including: pipe, pumps, fittings, heat exchangers, valves, towers and accessories, porous filtering media.	

NOTES:

[1] *No loss in strength for carbon to 3100 F; graphite to 4000 F*
[2] *Upper strength, values found in various specialty stocks.*

Prepared with the assistance of National Carbon Co., and The United States Graphite Co.

B&W *ERW Carbon Steel*
Mechanical Tubing



UNIFORM FROM TUBE TO TUBE

Uniform wall thickness and concentricity permit the frequent use of tubing in the "as is" condition, even for such rotating parts as conveyor rolls, thus eliminating costly machining operations. Fabricators who insist upon B&W Electric-Resistance-Welded Carbon Steel Mechanical Tubing *know* that they can use standard methods of joining, forming, and fabrication with complete assurance of uniform workability.

B&W ERW Tubing may be supplied *cold-rolled* or *hot-rolled*. Cold-rolled tubing is recommended where close limits are required on gage and inside diameter, where superior quality finish is necessary for plating, polishing or lacquering, or where close control of hardness or temper is desired. For most operations not involving these requirements, hot-rolled steel will prove equally satisfactory.

B&W Bulletin TB-333 contains valuable tips on how to make better products for less money, and is yours for the asking. Friendly Mr. Tubes —your nearby B&W Tube Representative—will be happy to discuss your specific tubing requirements at your convenience.

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa. — Seamless Tubing; Welded Stainless Steel Tubing
Alliance, Ohio — Welded Carbon Steel Tubing

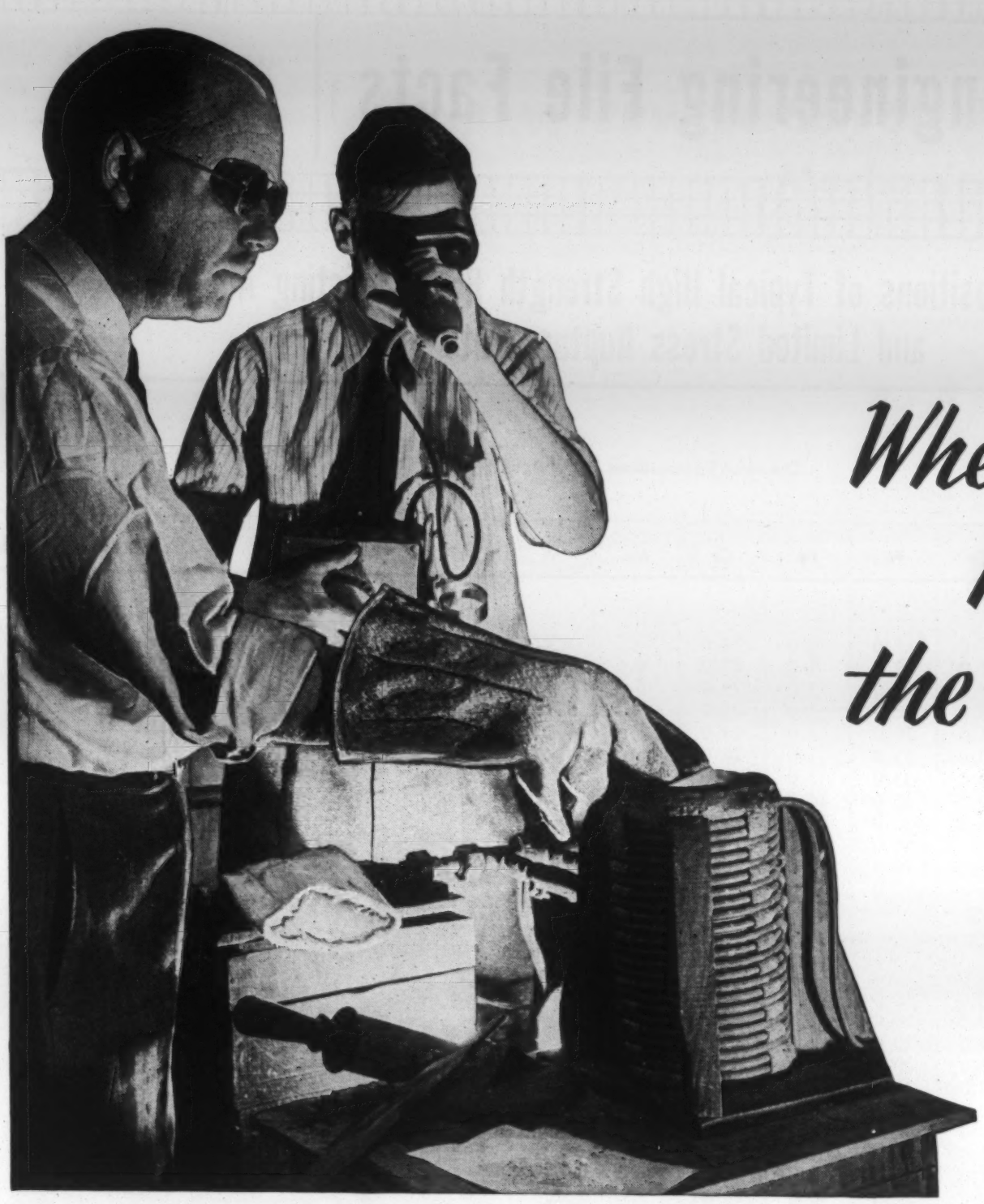
B&W SEAMLESS and WELDED TUBES

TA-1749 (E)

Nominal Compositions of Typical High Strength Heat Resisting Alloys and Limited Stress Rupture Data

Alloy	Chemical Compositions by Weight, %											Stress to Rupture Psi x 1000 at 1500 F	
	C	Co	Ni	Fe	Cr	Mo	W	Cb/Ta	Ti	Al	Other	100 Hr	1,000 Hr
CAST ALLOYS													
61 (HS23)	0.40	55.0	1.0	2.0	24.0	—	5.0	—	—	—	—	27.0	21.0
HS21	0.25	62.0	2.0	1.0	27.0	6.0	—	—	—	—	—	22.0	16.0
X63 (GE)	0.40	56.0	10.0	3.0	23.0	6.0	—	—	—	—	—	26.0	20.0
X40 (HS31)	0.50	55.0	10.0	1.0	25.0	—	7.0	—	—	—	—	28.0	23.0
L-251	0.40	54.0	10.0	1.0	19.0	—	14.0	—	—	—	—	28.0	23.0
422-19 (HS30)	0.40	50.0	15.0	1.0	26.0	6.0	—	—	—	—	—	27.0	21.0
6059 (HS27)	0.40	34.0	33.0	1.0	25.0	6.0	—	—	—	—	—	23.0	18.0
Refractaloy 80	0.10	30.0	20.0	14.0	20.0	10.0	5.0	—	—	—	—	19.0	—
HE-2048	0.40	15.0	30.0	21.0	26.0	4.0	2.0	—	—	—	0.15 B	20.0	14.0
Hastelloy C	0.10	—	56.0	6.0	16.0	16.0	4.0	—	—	—	0.3 V	18.0	13.0
1-1360	0.10	—	70.0	6.0	10.0	5.0	—	2.0	—	6.0	0.5 Be	45.0	32.0
95-M-255	—	—	67.0	1.0	—	25.0	—	—	—	6.0	—	—	—
WROUGHT ALLOYS TYPE I													
L-605	0.05	53.0	10.0	1.0	20.0	—	15.0	—	—	—	—	24.0	17.0
I-336	0.20	50.0	15.0	1.0	20.0	—	12.0	1.0	—	—	—	25.0	17.0
WF31	0.15	50.0	10.0	5.0	20.0	3.0	10.0	—	—	—	—	24.0	17.0
S-844 (V. 36)	0.30	44.0	20.0	2.0	25.0	3.0	2.0	2.0	—	—	—	23.0	16.0
S-816	0.40	43.0	20.0	3.0	20.0	4.0	4.0	4.0	—	—	—	24.0	18.0
25 Ni	0.15	40.0	25.0	2.0	19.0	—	11.0	1.0	—	—	—	27.0	22.0
Refractory	0.05	30.0	21.0	14.0	20.0	8.0	4.0	—	—	—	—	19.0	15.0
S-590	0.40	20.0	20.0	25.0	20.0	4.0	4.0	4.0	—	—	—	19.0	15.0
N-155 (CW)	0.10	20.0	20.0	32.0	20.0	3.0	2.0	1.0	—	—	0.15 B	18.0	13.0
Hastelloy X	0.10	2.0	48.0	18.0	21.0	9.0	1.0	—	—	—	—	—	—
CSA 39	0.10	—	27.0	40.0	19.0	9.0	3.0	—	—	—	—	20.0	15.0
Hastelloy B	0.10	—	66.0	5.0	—	28.0	—	—	—	—	0.3 V	17.0	11.0
WROUGHT ALLOYS TYPE II													
K-42-B	0.05	22.0	42.0	14.0	18.0	—	—	—	3.0	R	—	22.0	15.0
Refractaloy 26	0.05	20.0	37.0	17.0	18.0	3.0	—	—	3.0	R	—	29.0	18.0
Nimonic 90	0.05	20.0	54.0	1.0	20.0	—	—	—	2.0	1.0	—	28.0	18.0
Waspaloy	0.05	13.0	58.0	1.0	20.0	3.0	—	—	2.0	1.0	—	28.0	18.0
M-252	0.10	10.0	53.0	3.0	19.0	10.0	—	—	2.0	1.0	—	26.0	17.0
Nimonic 80 A	0.05	1.0	73.0	1.0	20.0	—	—	—	2.0	1.0	—	19.0	11.0
Inconel X	0.05	1.0	71.0	7.0	15.0	—	—	1.0	2.0	1.0	—	28.0	18.0
INTERMEDIATE ALLOYS													
G-18-B (CW)	0.40	10.0	13.0	53.0	14.0	2.0	3.0	3.0	—	—	—	48.0	35.0
16-25-6 (CW)	0.10	—	25.0	51.0	16.0	6.0	—	—	—	—	0.15 N	50.0	38.0
Discaloy	0.05	—	25.0	55.0	13.0	3.0	—	—	2.0	R	—	55.0	42.0
A-286	0.05	—	26.0	53.0	15.0	1.0	—	—	2.0	R	0.3 V	62.0	45.0
17W (CW)	0.50	—	19.0	63.0	13.0	1.0	2.0	—	—	—	—	—	—
HS-88 (CW)	0.10	—	15.0	69.0	12.0	2.0	0.5	—	—	—	0.1 B	52.0	42.0
19-9-DL (CW)	0.30	—	9.0	68.0	19.0	1.0	1.0	3.0	—	—	—	50.0	40.0
OTHER JET ENGINE ALLOYS													
Inconel	0.05	—	78.0	7.0	14.0	—	—	—	—	—	—	22.0	15.0
AISI 310	0.10	—	20.0	53.0	25.0	—	—	—	—	—	—	25.0	18.0
AISI 321	0.06	—	10.0	70.0	18.0	—	—	—	0.5	—	—	29.0	18.0
Crucible 422	0.20	—	1.0	82.0	13.0	1.0	1.0	—	—	—	0.3 V	25.0	17.0
H-40	0.25	—	R	93.0	3.0	0.5	0.5	—	—	—	0.8 V	—	—
17-22-AS	0.30	—	R	—	1.0	0.5	—	—	—	—	0.3 V	—	—

From a paper by J. B. Meierdirks, Jr. before AISI regional meeting, Philadelphia, Dec., 1952



When Nobody Knows the Answer

One of these days you may come face-to-face with a metal problem that does not seem to have an answer.

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When nobody knows the answer, Inco's metallurgists keep going until they have investigated all possible metals and alloys that might do the job. In fact, the men in Inco's Technical Service (and in their Corrosion Engineering and High Temperature Engineering Services, as well) have one primary goal: to help you determine whether an Inco Nickel Alloy or some *other* metal will serve your purpose best.

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NIMONIC® ALLOYS • NICKEL • LOW CARBON NICKEL • DURANICKEL®

Definitions of Alloys as Used in the Copper and Brass Mill Products Industry

COPPER: The element copper commercially pure or alloyed with not more than 1% of other elements. The term "copper" is generally modified to indicate either its method of production or the alloying material that is present. Typical examples are:

Electrolytic Tough Pitch Copper
Deoxidized Copper
Oxygen-free Copper
Fire Refined Copper
Silver-bearing Copper
Phosphorized Copper
Tellurium Copper
Sellenium Copper
Leaded Copper

BRASS: An alloy of copper with zinc as the principal alloying element, with or without small quantities of some other elements.

Gilding, 95%
Red Brass, 85%
Low Brass, 80%
Cartridge Brass, 70%
Yellow Brass
Muntz Metal
Forging Brass
Naval Brass
Aluminum Brass

Some Brasses, because of their appearance or because of some particular property, are commercially called bronzes, for example:

Commercial Bronze, 90%
Leaded Commercial Bronze
Architectural Bronze
Manganese Bronze

Brasses to which lead has been added to improve machinability are known as "Leaded Brasses" and include the following:

Low-leaded Brass
Medium-leaded Brass
High-leaded Brass
Extra-high-leaded Brass
Free-cutting Brass
Leaded Muntz Metal
Free-cutting Muntz Metal

The alloy commercially known as "Nickel Silver" is a Brass in which the element nickel has been substituted for part of the zinc. Where two numerals appear after the name, they indicate the percentage of copper and nickel, respectively. For example:

Nickel Silver, 55-18
Nickel Silver, 65-15
Leaded Nickel Silver, 61.5-12
Extruded Leaded Nickel Silver

BRONZE: Originally the term for copper alloys having tin as the only or principal alloying element. In modern usage, the term "Bronze" is seldom used alone, and the terms "Phosphor Bronze" or "Tin Bronze" are considered preferable for indicating the copper-tin alloys. Thus:

Phosphor Bronze, 5%
Free-cutting Phosphor Bronze
Phosphor Bronze, 8%

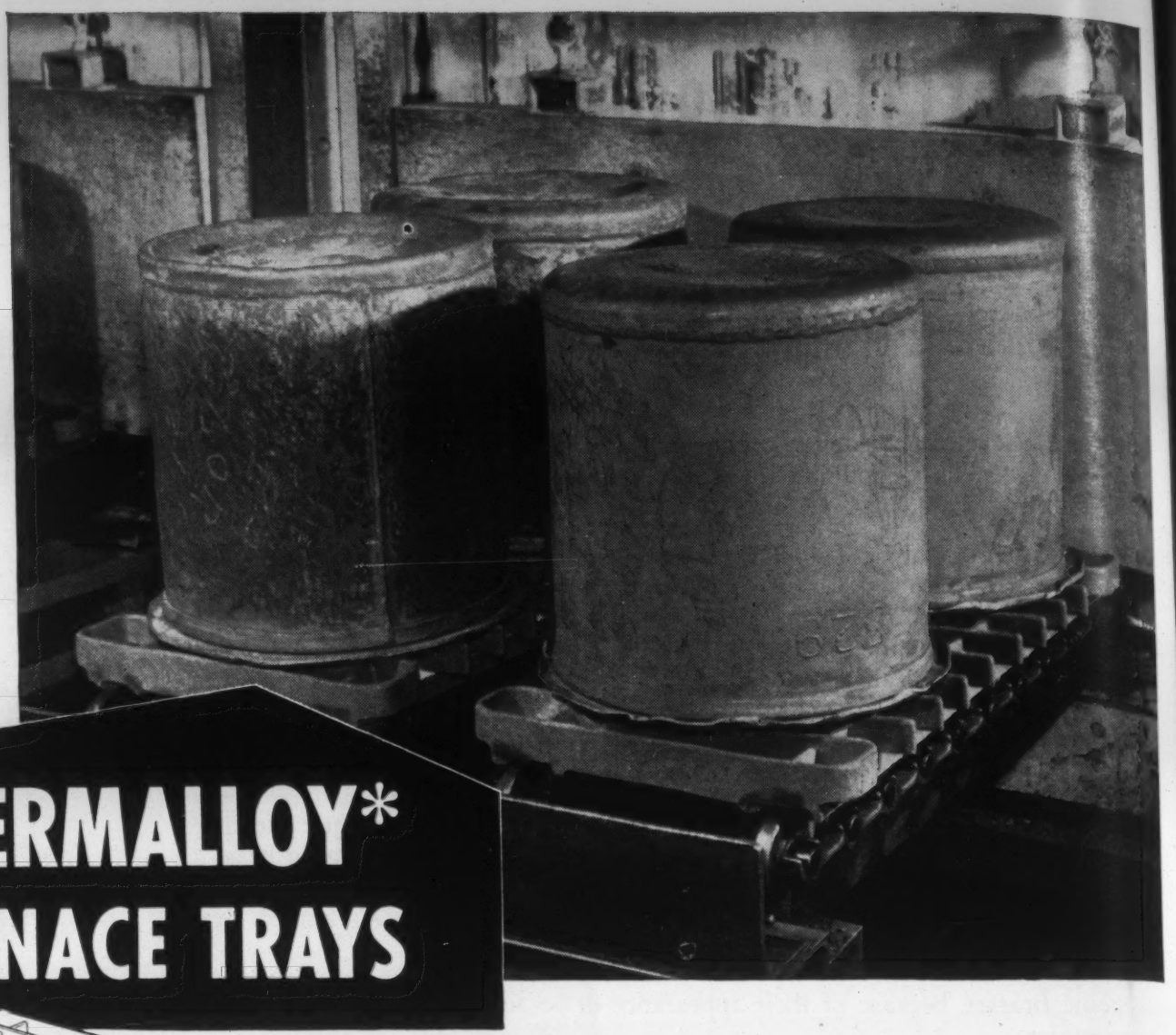
The term "Bronze" suitably modified has been extended to apply to any of a variety of copper-base alloy systems particularly where the element alloyed with the copper is present in not much more than 10%. For example:

Aluminum Bronze (Copper with aluminum as the principal alloying element)
High Silicon Bronze (Copper with silicon as the principal alloying element, with or without small percentages of other elements)
Low Silicon Bronze (Similar to High Silicon Bronze with less silicon)

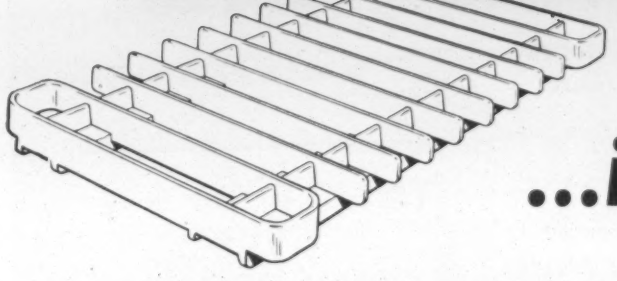
These usages for the term "Bronze" have gained widespread acceptance. This, of course, excludes the Brasses which include the word "Bronze" in the title but which, by definition, are actually Brass. (See Brass.)

CUPRO NICKEL: Cupro Nickel, an alloy of copper and nickel with the nickel content usually being 10, 20 or 30 percent, does not fall readily into any of the foregoing definitions.

Courtesy of Copper & Brass Research Association



THERMALLOY* FURNACE TRAYS



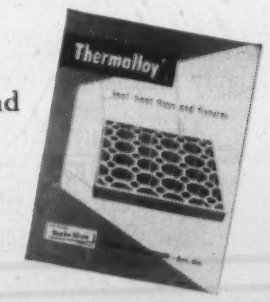
...in service over 10,000 hours!

A large automotive parts manufacturer "pack-carburizes" drive pinions in pots conveyed two on a tray through a gas-fired furnace where temperatures range up to 1700°F. Previous designs of the furnace tray cracked, warped and scaled quickly, with average service life limited between 100 and 600 hours.

This manufacturer asked Electro-Alloys engineers how service life of these trays could be extended. Electro-Alloys designed a new furnace tray . . . cast it in a grade of heat-resistant Thermalloy best suited for long carburizing service. Two years ago, these Thermalloy trays were installed. Today, with over 10,000 service hours each, they are still in use.

Thermalloy is not one alloy but a group of alloys—each developed to meet specific high-temperature operating conditions. Electro-Alloys produces many types of high heat-resistant Thermalloy castings such as muffles, retorts, trays, fixtures, baskets, rollers. In many cases too, Electro-Alloys engineers can help you redesign your heat-treating parts in Thermalloy to give more operating hours per dollar. Call your nearest Electro-Alloys representative for full information or write Electro-Alloys Division, 4001 Taylor Street, Elyria, Ohio.

Write for new Thermalloy Tray and Fixture Bulletin T-226.



*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO

New Materials and Equipment

Plastic Pipe Resists Chemical Corrosion

An extruded, rigid, unplasticized polyvinyl chloride pipe is now available from *Alpha Plastics, Inc.*, 14 Northfield Rd., West Orange, N. J. It is made of "Alpha Forty", a special compound of vinyl chloride polymer processed without the aid of plasticizers or co-polymers, as distinct from "hard vinyls" which are produced by reducing the plasticizer content. However, the company states that "Alpha Forty" retains, unmodified, the properties of straight p.v.c. and produces a tough, rigid pipe with high chemical resistance.

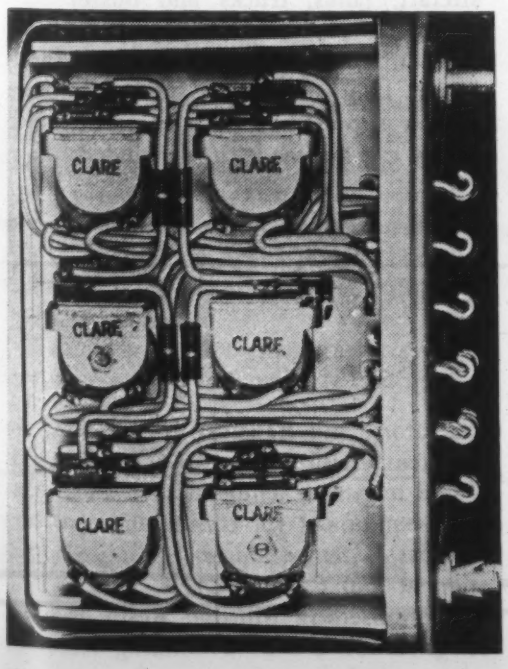
At ordinary temperatures "Alpha Forty" is unaffected by alkalies, acids, salts, oxidizing agents, oils, greases, alcohols, gasolines and carbon tetrachloride, though a swelling action will be produced by some organic solvents such as ketones, ethers, chlorinated hydrocarbons, and some aromatic hydrocarbons.

Ultimate tensile strength of this compound is of the order of 7,000 psi; compressive strength is 12,000 psi; flexural strength is 13,000 psi. Impact strength, measured by ASTM test D256-43T, is 0.75 ft lb per in. of notch, while deformation under load is 0.8% in 24 hr. Water absorption is said to be minor, 0.2% in 24 hr at 75 F, and heat distortion occurs only above 165 F.

"Alpha Forty" pipe is stocked in 10 and 20 ft lengths, standard and extra heavy weights, from ½ to 4 in. nominal pipe size. Styles include standard tees, 45 and 90 degree elbows, nipples, plugs, couplings, and blind or companion flanges.

Extruded plastic pipe combines chemical resistance with toughness and rigidity.

Rubber Coated Electrical Insulation



Rubber coated fiber glass insulation protects wiring in cramped quarters and maintains flexibility.

A new line of Class H fiberglas tubing and sleeving that is said to have unusual dielectric strength and to keep its flexibility throughout the life of electrical equipment to which it is applied is now available as a result of the recent introduction of SE-100 silicone rubber coating compound by *General Electric Co.'s Silicone Products, Dept.*, Waterford, N. Y.

This new insulation, BH "1151", is produced in 27 sizes by the Bentley, Harris Manufacturing Co., Conshohocken, Pa., from braided fiberglas coated with the heat resistant silicone rubber. Its electrical and physical properties are said to be unaffected by continuous operation through a temperature range of —90 to 400 F. It will also withstand 450 F for 96 hr, 500 F for 4 hr and 600 F for 15 min.

G-E states that the silicone coating gives BH "1151" an average minimum electrical break-down ranging from 7,000 volts for NEMA class H-A-1 to 1,500 for Class H-C-2. Electrical resistance is 100,000 megohms after 48 hr tests at 77 F (25 C) and 50% relative humidity. The material can be twisted and bent without crazing or cracking or losing electrical strength.

One user of the insulation reports that it can be dressed around sharp metal corners or pressed tightly against metal parts in small enclosures required by the armed forces miniaturization program. The sleeving protects their equipment against lead breakage commonly caused by prolonged frequency vibration, forms no residue gases or films, and contains no foreign matter which might interfere with the precise mechanical parts or gaseous atmospheres in which their relays are mounted. Moreover, the silicone does not melt, deform or outgas when accidentally touched by a hot solder tip.

The SE-100 silicone rubber coating material is useful as an encapsulating material for coils and cores, and as an impregnant for heater ducts, gaskets, seals and diaphragms. It is available from G-E as a base stock and as a dispersion.

New Materials and Equipment continued

Cast Aluminum for Use in Master Tooling

Thick cast aluminum plates and bars, precision machined to high finish and flatness for tool and die use are now available from *Reynolds Metals Co.*, Louisville, Ky. This plate is reported to be especially suited for use in the construction of hydro-press form blocks, hydro stretch form dies, jigs, fixtures and other tooling because of its fine molecular grain structure, high tensile strength, a 32-microinch surface finish, and a flatness of ± 0.005 in. or less. The company states that because of its free machining characteristics, this plate is particularly adapted to die work, replacing Kirksite as a die material.

Cast aluminum plates are used in the aircraft industry for drill jigs as well as formers, stiffeners and stringers for large assembly jigs. Set-up tables for sub-assembly jigs, router bases and layout tables all employ this cast plate to advantage, the company states. In addition to the light-weight and low fabricating cost of this material, cast aluminum, when used in master tooling, eliminates thermal problems resulting from uneven expansion and so is widely used for jigs, fixtures and form blocks.

The large size cast aluminum bars are said to prove advantageous as a fixture base on spar mills, where they replace Kirksite at approximately one-third the weight and at reduced cost. Conventional machining time can be saved readily, since the bars arrive in a finished condition.

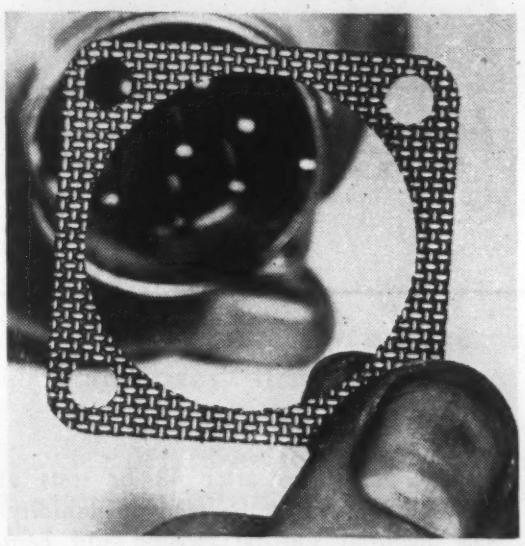
Reynolds Co. states that their casting technique eliminates any possibility of internal shrinks or voids and reduces inclusions to an absolute minimum.

Physical properties of the Reynolds cast aluminum plate and bar stock are listed as follows: Tensile strength, nominal 25,000 psi as cast; Brinell hardness, average 70 (B scale); elongation 0.5 to 1.5% in 2 in.

The plate will be available in a standard width of 48 in. and three standard lengths of 96, 120 and 144 in., thicknesses ranging from ½ to 8 in.

Completely machined bars will be available up to 8 in. wide, 8 in. thick, and 12 ft. long.

Conductive Gasket Material Drains Static Electricity



Aluminum screening in gasket insures inter-flange electrical contact, allowing static electricity to drain from equipment.

Vulcanized Rubber & Plastics Co., Morrisville, Pa., announces the manufacture of a new, highly conductive gasket material which will allow static electricity to drain from electrical and electronic equipment rather than remain "trapped" by non-conducting gaskets. It is designed primarily for use in mounting electrical equipment in automobiles and aircraft, and for general use in radio and electronic equipment. It is said to be effective under difficult conditions of high receiver intensity and low signal strength.

The gasket material consists of aluminum wire screening, the interstices of which are filled with neoprene. Both surfaces of the material are buffed to insure uniform gage and smoothness, and to expose the aluminum wire for a clean electrical contact with the flanges of the connector. In addition to providing conductivity, the aluminum wire structure gives a dimensional stability which makes for easy assembly and minimizes distortion under flange pressure. Neoprene is used as the filler to provide lasting resilience since it is said to resist deterioration by oil, heat and ozone.

The manufacturer cites the following as illustrative of the material's many successful applications: in antistalling vibrators and hydraulic oil lines in aircraft, for mounting motors on radar antennae and magnetos on aircraft engines, with aircraft ignition harnesses and leads, and with flange mounted connectors on aircraft, tanks, trucks and busses.

The material can be supplied either in the form of cut gaskets or as uncut sheets, 19 in. long and 15 in. wide. Thickness as now supplied is 0.02 in.; other thicknesses can be made if demanded.

Electrical Insulation Varnishes

A new series of silicone electrical insulation varnishes have been developed by *Linde Air Products Co.*, a division of Union Carbide and Carbon Corp., 30 E. Forty-Second St., New York 17, to fill the need for a line of coatings that provide Class H insulation for applications ranging from flexible glass cloth or tape to rigid tubular transformer insulation.

Silicone Coating Varnish R-61 is designed for glass cloth and tape applications where the greatest possible flexibility is required, and is said to meet the requirements of a Class I or Class II silicone insulation under Military Specification MIL-I-17205A. The manufacturer states that the R-61 treated cloth exceeds all of the individual electrical and mechanical tests called for under this specification, including exceptional low-temperature flexibility.

Silicone Impregnating Varnish R-62 is used in the coating of electric coils, armatures, and stators in electric motors, generators, and transformers intended for high-temperature or heavy-duty service. It is said to permit temperature rises in electrical equipment for continuous operation at Class H temperatures, or limited operation at 480 F (250 C).

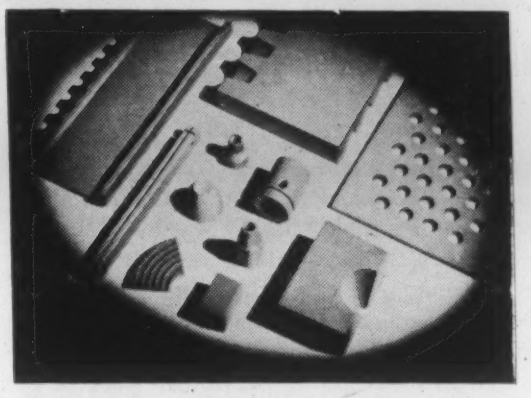
Thermosetting Silicone Resin R-63 is designed for use as a bonding resin for asbestos, glass, mica or other mineral filler, and as a protective and release coating for numerous applications according to company reports.

High Temperature Ceramic for Fixtures and Jigs

A new ceramic, A1SiMag 539 is currently providing an excellent material for fixtures, jigs and work holding devices for fast production line handling of brazing, welding, electronic heating, and flame polishing. According to the manufacturer, *American Lava Corp.*, Chattanooga 5, Tenn., the material is also valuable for making pins, pads, plates, spacers and kiln furniture for high temperature sintering operations. Nozzles for welding tips and other extremely high temperature devices have given outstanding performance.

The ceramic is a relatively fine grained silicon carbide material. Due to the difficulties of machining this highly abrasive material, there are some limitations on the manufacture of complicated shapes.

Where high temperatures are involved, or where rapid thermal changes occur, the material is said to have superior properties. It has been repeatedly heated white hot and quenched in dry ice without fracturing.



Some of the many shapes possible with the new silicon carbide ceramic.

Anti-Rust Compound Protects Iron and Steel

A new, mildly alkaline, rust-preventative compound has been announced by *Enthone, Inc.*, 442 Elm St., New Haven 11, Conn. It is a water-soluble powder used in a concentration of 1 oz per gal which is said to protect iron and steel against rusting in 100% humidity for several weeks or more. Enthone Compound NR-31 contains surface active ingredients to provide for uniform distribution of the rust-proof compound over the surface of the metal and to speed drying.

The 1 oz to 1 gal concentration of this compound produces mild detergent effects; however, if greater detergent action is desired, concentrations up to 4 oz per gal can be used.

The manufacturer suggests the following uses for Compound NR-31:

1. Rough cleaning and temporary rust protection of iron and steel including cast iron. The solution can be applied either in a still tank or a spray wash tank, and the compound is allowed to dry on the work.

2. Added to solutions used for storing articles made of iron or steel.

3. To prevent rusting of work after it has been cleaned and pickled in acids. The alkaline nature of the compound insures that traces of acid will be neutralized in case acid has been trapped in pores.

4. For addition to hot water for drying of complicated parts where water might be trapped in crevices and recesses.

5. For power spray washing of steel parts where rust protection and detergency are both needed.

Compound NR-31 is available in 100 and 300 lb fiber packed drums.

New Rubber Film Will Seal To Itself

A new rubber film which combines properties of plastics and man-made rubber and can be electronically sealed to itself has been developed by *The B. F. Goodrich Co.*, Akron. "Vulcafilm" permits the assembly of shapes or vessels of any size with fused, homogeneous seams which are said to be stronger than the material itself, eliminating cementing or taping of seams.

According to the manufacturer, this new material can be combined with many types of fabric reinforcement, and the compound itself can be varied to obtain resistance to oil, gasoline, sunlight, heat, cold, abrasion and acids.

The principal use of Vulcafilm to date has been in the manufacture of oil tank diaphragms by Hammond Iron Works, Warren, Pa. These diaphragms are said to virtually eliminate evaporation from stored petroleum products, sealing the product in and sealing air out. In one design, the diaphragm rises and falls with the surface of the liquid; while in another, it is suspended in space by the slight pressure of the expanding vapors. When installed in tanks containing sour crude oil, the diaphragm is said to protect tank walls and top from the corrosive action of sulfuric fumes.

Other products which have been made of Vulcafilm include inflatable pillows to prevent damage caused by the shifting of freight cargo, and tank liners for water cooling towers.

New Wood Binder Developed

Monsanto Chemical Co.'s Plastic Div., Springfield, Mass., announces the availability of a new phenolic resin, Resinox 743, for use as a binder for granulated wood, which, it is said, can convert sawdust and other wood wastes into new raw materials for the manufacture of furniture, housewares and toys.

Finely divided and non-lumping, this resin is said to combine the two desirable properties of high flow and fast cure, allowing a deep penetration of the wood mass and production economies.

The company states that bits of granulated wood bonded together with Resinox 43 have consistently demonstrated good strength properties, good screw-holding power and a high resistance to water.

New Materials and Equipment continued

Mica Binder Increases Flexibility of Insulation

A new grade of sheet mica insulation has been developed by the *General Electric Co., Laminated and Insulating Products Div.*, Pittsfield, Mass. The mica can be stored twice as long as ordinary bonded mica products and combines the advantages of extreme flexibility and low-binder content enabling replacement of several different grades previously stocked for special applications.

Developed for motors and generators operating up to 302 F (150 C), G-E believes that its 77520 flexible sheet mica is the first product ever to impart flexibility with a binder content of only 7 to 11%. An unusual combination of physical properties results from the use of a new resin recently developed as a bonding agent for metal, but never before used as a mica binder. Present in such small amounts, the resin will not ooze when heated under pressure, yet imparts such flexibility that sheets up to 10 mils thick can be bent around a one-half inch mandrel without chipping. Thicker sheets can be bent around a one inch mandrel with no harmful effects, the company states.

The new binder also prevents G-E 77520 sheet from delaminating, flaking or stiffening when stored for six months without the use of separators, while the maximum storage life of most conventional bonded mica products is said to be approximately three months.

The flexible sheet mica is easily formed without heating for use in armature slots under end windings, at crossovers and under field coil terminals. Minimum dielectric strength is 350 volts per mil for sheets up to 20 mils and 300 volts per mil for thicker material.

New Glass Fiber Reinforced Molding Compound

Production of Glaskyd, a new, improved Fiberglas-reinforced molding compound, is now underway in the *Perrysburg Laboratories, Inc.*, Perrysburg, Ohio. Glaskyd, containing chopped Fiberglas strands and special formulations of alkyd resin, is extruded and made available in rope-like form. Special equipment for cutting and feeding the compound to molds permits higher-speed, more completely automatic molding cycles than heretofore possible with glass-reinforced materials, the company states.

The material has a specific gravity of 2.0; impact strength of 4 to 5 izod; flexural strength of 15,000 to 20,000 psi; a heat distortion point over 392 F and arc resistance 180 sec. Basic color of the material is white. It is receptive to many colors and molds to surface smoothness comparable to that of decorative plastics.

Non-Hygroscopic Flux Aids Aluminum Joining

A non-hygroscopic flux for joining aluminum has been announced by *Eutectic Welding Alloys Corp.*, 172nd St. and Northern Blvd., Flushing, N. Y., which is said to eliminate corrosion caused by the absorption of water from the atmosphere. The company states that the great majority of corrosion problems normally found in aluminum joining, as a result of the corrosive properties of the slag of conventional fluxes, can be minimized with Eutector Flux 190NC.

The activating flux is said to lower surface tension and provide greatly improved wettability. The manufacturer claims that while in some instances the nature of the slag residue might result in some degree of corrosive activity, the degree of corrosion is but a small fraction of what has heretofore been known.

The new flux works with a four-way action: It cleans the joint area by removing all oxides; acts as an automatic heat indicator (the melting of the flux indicates the approximate joining heat); and promotes smoother and faster flow of alloy, requiring less material per joint.

Coating for Aluminum Increases Corrosion Resistance

"Alodine" No. 1200, a new type of protective coating chemical for unpainted aluminum, developed by the *American Chemical Paint Co.*, Ambler, Pa., is about to go into production, the company announces. This new chemical is said to form an amorphous mixed metallic oxide coating of low dielectric resistance which gives unusually high corrosion resistance and a paint bond that approaches closely that obtained with earlier types of "Alodine" and conforming to specification MIL-C-5541.

The new No. 1200 is the only essential chemical needed to prepare the coating bath and the final rinse bath, the company states. It can be used in tanks in an immersion process, or in a multi-stage power washer in a spray process, or with brush or portable spray equipment in a manual process.

Process sequence for all three methods of application is the same as for other standard grades of Alodine:

1. Pre-cleaning
2. Rinsing
3. Alodizing
4. Rinsing
5. Acidulated rinsing
6. Drying

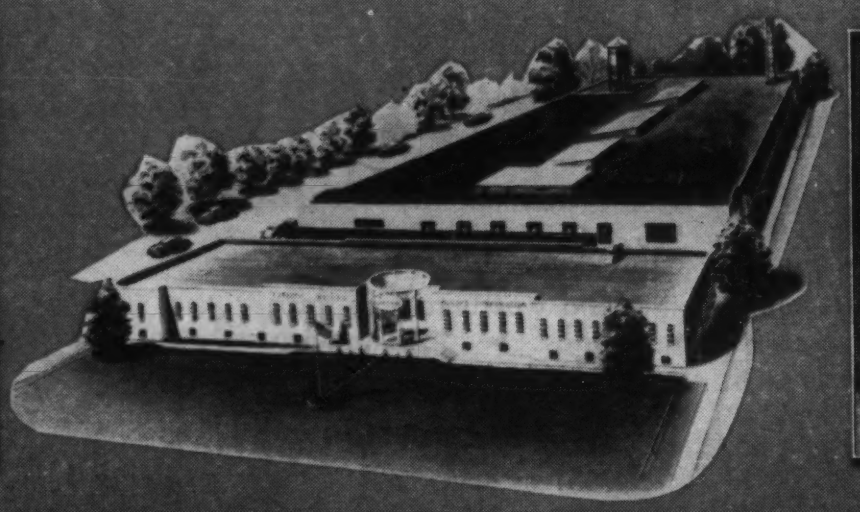
"Alodine" No. 1200 is recommended specifically for coating wrought products which are not to be painted or are to be only partially painted; and for coating casting and forging alloys.

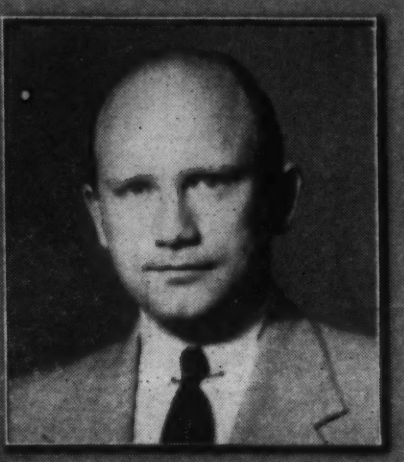
Coating time in an immersion process ranges from 2 to 8 min and in a mechanized spray process about 30 sec. Baths are operated at room temperatures (70 to 100 F), requiring heating only if bath becomes cold after a down period.

(Continued on page 150)

WHO INVENTED "Low Temperature Welding Alloys*"?

*A registered Trademark of Eutectic Welding Alloys Corporation





In 1906, J. P. H. Wasserman for the first time observed the phenomenon of "surface alloying" in brazing—and adapted it into his new process of non-fusion welding, later perfected by his son, Rene D. Wasserman, who, in 1940, founded "EUTECTIC" in New York. Eutectic Welding Alloys Corporation are the inventors, patentees and sole manufacturers of "Eutectic Low Temperature Welding Alloys",® that minimize or completely eliminate the dangers that conventional high heat rods invite, such as: warping, distortion, stresses, embrittlement, etc. They are now used in over 78,000 industrial plants throughout America and sold and serviced in over 67 countries throughout the world! These **new and different products, developed by "America's Leading Institution Devoted to the Research and Manufacture of Specialized Metal-Joining Alloys" are today saving millions of dollars for others and can save time, money and materials for YOU too!**

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New Engineering Material Features Resilience and Resistance to Wear, Tear, and Chemicals

Developed for Military Needs; Now Available for Civilian Use Under Name

GAM-EN-WOOD

An important new industrial material, GAM-EN-WOOD, has been developed by the product research laboratories of Gamble Brothers, Incorporated, and United States Rubber Company.

GAM-EN-WOOD combines the desirable properties of wood with those of a new group of synthetics. The result is a highly serviceable new product which can be engineered to fill many specific requirements better than any previously available material.

This outstanding new product is formed by moulding the new synthetic, Enrup, over properly selected, cured, and machined hardwood parts. The resulting bond is permanently inseparable.

GAM-EN-WOOD affords excellent resistance to heat, abrasion, and weather. It is impervious to most chemicals and greases. It has the further advantages for many applications, of being a non-conductor of electricity and free from arc-track.

Among its many applications, GAM-EN-WOOD is especially suited for the following: Laboratory and Work-Table Tops, Industrial Flooring, Truck Floors, Baffles, Conveyor Rolls, Conveyor Slats, Wood Core Factory Truck Wheels, Electrical Panels, Tank Linings, Railroad Crossing Planks.

For more detailed information, write for our free brochure "GAM-EN-WOOD . . . the New Answer to Many Old Problems." No obligation.

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New Materials and Equipment

Small, Portable Industrial X-Ray Unit

A new Norelco portable industrial x-ray unit (MG 160) that fits into the trunk of an automobile, and is designed especially for rapid inspection of welds, pipe lines, power plant, ship and aircraft equipment, is available from the *X-ray Dept., Non-Destructive Testing Div., North American Philips Co., Inc.,* 750 S. Fulton Ave., Mt. Vernon, N. Y.

The new unit is said to be unique since the x-ray tube head also contains the high tension generator of 150,000 v output. It weighs only 143 lb. The accompanying control is equally compact and weighs only 80 lb. The complete unit weighs only 223 lb.

The novel arrangement of tube and generator in one housing eliminates the need for high tension cables, always a possible source of trouble. The x-ray tube is fan-cooled and has an end port which provides maximum usefulness in handling various types of close-in work. Combination tube and generator unit has a diameter of only 10⅝ in. and is 35 in. long. Where desired, the diameter can be reduced to 8½ by eliminating the removable guards.

Power supply for the unit can be either 115 or 230 v a.c. Current drain is 20 amp.

Heat-Resistant Insulating Varnish

A new high heat-resistant insulating varnish, designed to provide outstanding service even under high temperature conditions, has been announced by *Irvington Varnish & Insulator Co.,* 6 Argyle Terrace, Irvington 11, N. J.

Called Irvington #180, the new varnish has undergone extensive laboratory and preliminary field tests which indicate no

In a *NEW* design . . . a *NEW* machine . . . to achieve the *BEST*

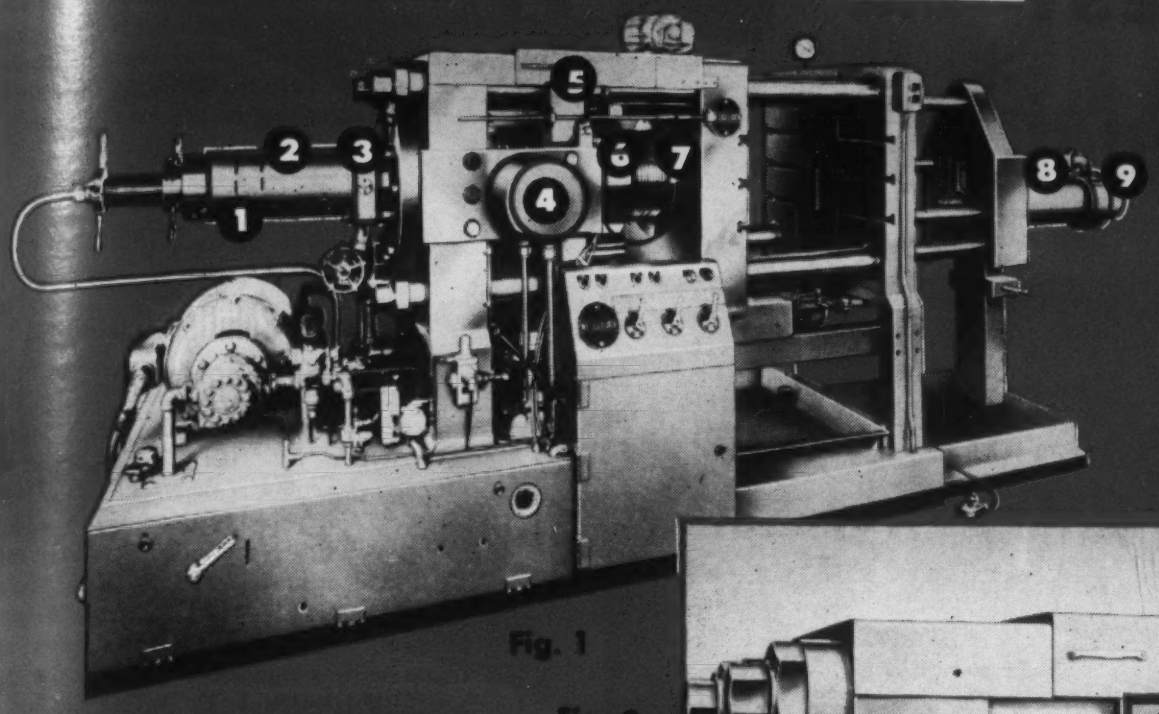

Fig. 1

1 PISTONS
2 CYLINDER SLEEVE
3 CYLINDER ROD HEAD
4 CYLINDER SLEEVE
5 PLATEN
6 ADJUSTING NUT
7 RETAINING RING
8 CYLINDER SLEEVE
9 CYLINDER HEAD

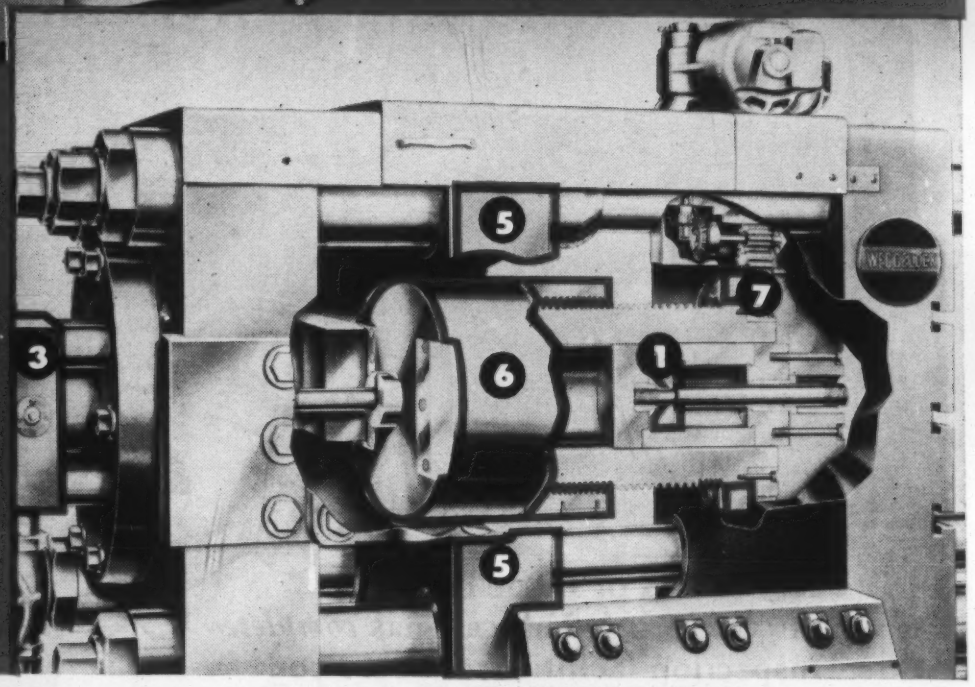

Fig. 2

Specify MEEHANITE® CASTINGS!

IN THIS NEWLY **designed die casting** machine (Fig. 1), built by Cuyahoga Industries, Inc., Cleveland, Ohio, parts required to provide top quality, maximum engineering properties, are Meehanite metal.

As can be seen from the parts indicated (Figs. 1 & 2), such castings must be dense, uniform, free from defects, rigid, strong, and tough. Because of the unique control processes used in the manufacture of Meehanite metal, these engineering characteristics are achieved in the right combination for the application.

Designers and manufacturers of machinery and machine tools have developed a confidence born of years of success with Meehanite components and turn to them regularly to solve every important design problem.

Consult your Meehanite foundry FIRST for engineering service and assistance, and ask for a copy of the new 24 page bulletin "Meehanite Castings Build BETTER Machine Tools".

MEEHANITE®

NEW ROCHELLE, NEW YORK

MEEHANITE MEANS BETTER CASTINGS

MEEHANITE FOUNDRIES

American Brake Shoe Co.	Mahwah, New Jersey
The American Laundry Machinery Co.	Rochester, New York
Atlas Foundry Co.	Detroit, Michigan
Banner Iron Works	St. Louis, Missouri
Barnett Foundry & Machine Co.	Irvington, New Jersey
E. W. Bliss Co.	Hastings, Mich. and Toledo, O.
Builders Iron Foundry	Providence, Rhode Island
Compton Foundry	Compton, Calif.
Continental Gin Co.	Birmingham, Alabama
Crawford & Doherty Foundry Co.	Portland, Oregon
The Cooper-Bessemer Corp.	Mt. Vernon, Ohio and Grove City, Pa.
M. H. Detrick Co.	Newark, N. J. and Peoria, Ill.
Empire Pattern & Foundry Co.	Tulsa, Oklahoma
Farrel-Birmingham Co., Inc.	Ansonia, Connecticut
Florence Pipe Foundry & Machine Co.	Florence, New Jersey
Fulton Foundry & Machine Co., Inc.	Cleveland, Ohio
General Foundry & Manufacturing Co.	Flint, Michigan
Greenlee Foundry Co.	Chicago, Illinois
The Hamilton Foundry & Machine Co.	Hamilton, Ohio
Hardinge Company, Inc.	New York, New York
Hardinge Manufacturing Co.	York, Pennsylvania
Johnstone Foundries, Inc.	Grove City, Pennsylvania
Kanawha Manufacturing Co.	Charleston, West Virginia
Koehring Co.	Milwaukee, Wisconsin
Lincoln Foundry Corp.	Los Angeles, California
London Concrete Machinery Co. Ltd.	Brantford, Ontario
E. Long Ltd.	Orillia, Ontario
Otis Elevator Co., Ltd.	Hamilton, Ontario
Palmyra Foundry Co., Inc.	Palmyra, New Jersey
The Henry Perkins Co.	Bridgewater, Massachusetts
Pohlman Foundry Co., Inc.	Buffalo, New York
The Prescott Company	Menominee, Mich.
Rosedale Foundry & Machine Co.	Pittsburgh, Pennsylvania
Ross-Meehan Foundries	Chattanooga, Tennessee
Shenango-Penn Mold Co.	Dover, Ohio
Sonith Industries, Inc.	Indianapolis, Ind.
Standard Foundry Co.	Worcester, Massachusetts
The Stearns-Roger Manufacturing Co.	Denver, Colorado
Traylor Engineering & Mfg. Co.	Allentown, Pennsylvania
Valley Iron Works, Inc.	St. Paul, Minnesota
Warren Foundry & Pipe Corporation	Phillipsburg, New Jersey

"This advertisement sponsored by foundries listed above."

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UNITCASTINGS
are consistently better!

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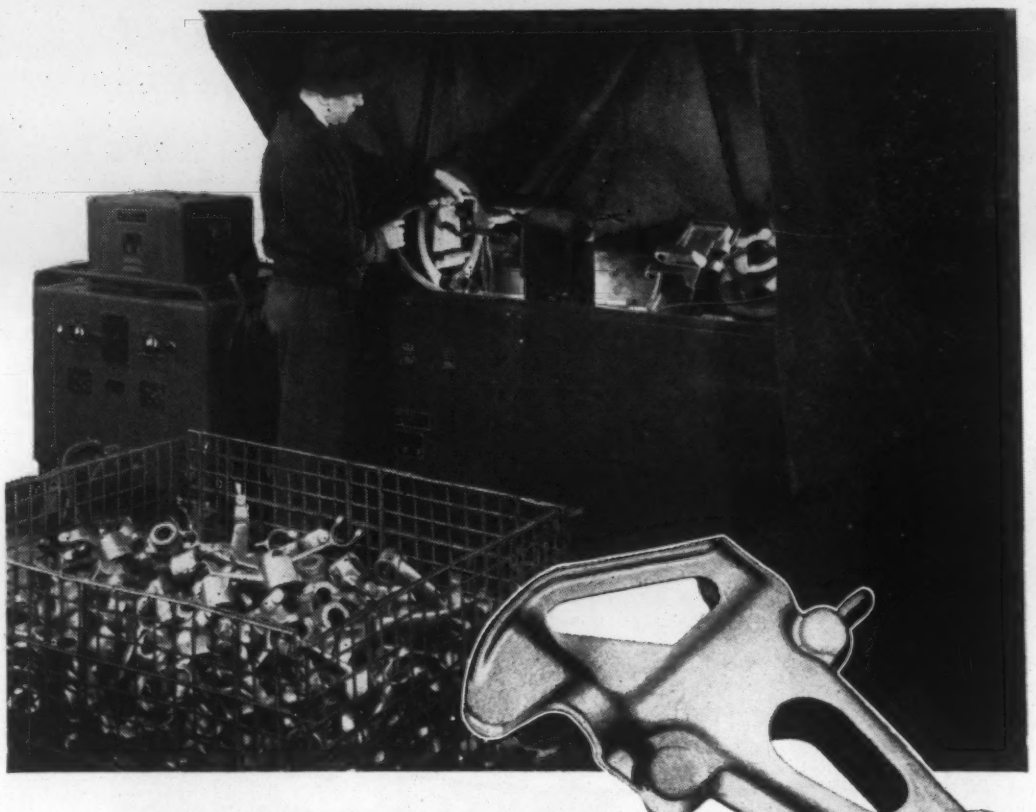
..every which* way!



Regardless of shape or size of the casting, Unitcast has *complete* inspection facilities to assure you uniformly *sound* steel castings *every time.*

* Magnaflux . . *either the wet or dry method.*
Magnaglo . . *particle inspection (or Zyglo).*
Gamma Ray or X-Ray . . *we can "see through" your casting.*
Mechanical . . *yes, we section-cut to check internal soundness.*

Whatever inspection method is needed on *your* steel castings, *we have it!* Another example of the *thorough quality control* you get at Unitcast.

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Our steel casting specialists welcome the opportunity of working with you on your parts problems... their suggestions at the design stage can pay you continuous dividends.

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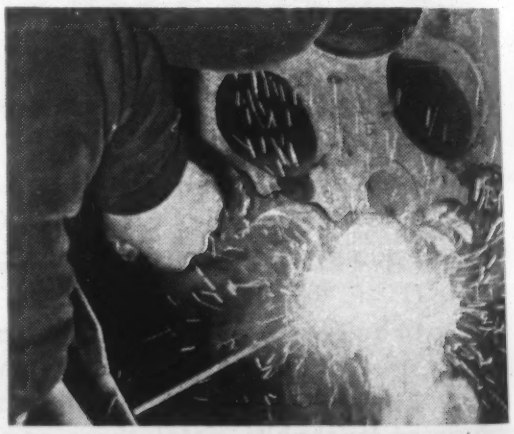
New Materials and Equipment

adverse effects on numerous electrical applications when operated at elevated temperatures as high as 356 F. It has a clear color, excellent oil and moisture resistance, with a dry dielectric strength of 2100 v per mil, according to the manufacturer.

Chemical Solution Enhances Pickled Metals

A new chemical solution, Black Magic "Pik-Aide", has been announced by *Mitchell-Bradford Chemical Co.*, 2446 Main St., Stratford, Conn. When added to hydrochloric (muriatic), sulfuric and nitric acid pickling solutions Black Magic "Pik-Aide" is said to produce a bright, uniform, fast and economical pickling action with a minimum of attack on the base metal, eliminating pitting action.

The solution is used in a concentration of 2½ qt per 100 gal of pickling solution, is said to be non-toxic and non-flammable, and will add cleaning action to acid pickle, removing any soils not removed prior to pickling.



New Hard-Surfacing Welding Electrode Offered

A new welding electrode, designed for build-up work and hard-surfacing applications wherein the deposited metal can be machined or flame hardened, has been announced by the *General Electric Company's Welding Department.* It is recommended where a higher hardness deposit is desired than that obtainable with electrodes used for under layers.

The new electrode, designated G-E Type W-98, is a heavy-covered flame-hardening rod that can be used in all positions. The arc is of the steady-spray type, similar to that produced by the E-6013 electrode.

The W-98 can be used in build-up

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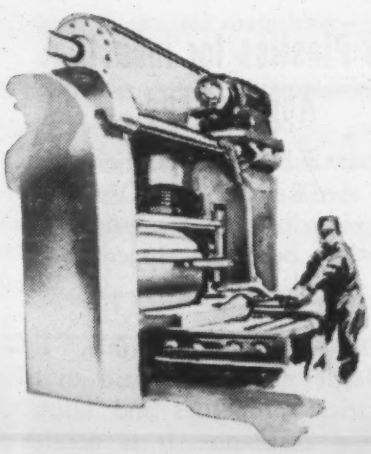
INVESTIGATE

your possible uses of "as rolled" commercial grade Magnesium plate replacing heavier metals or wood. Steel is 400% heavier, aluminum is 50% heavier. Use MAGNESIUM PLATE for:

INPLANT EQUIPMENT—anything lifted or carried, moved or pushed; many MATERIAL HANDLING uses; weight reduction on ANYTHING AUTOMOTIVE: cars, trucks, trailers, tractors, boats and ships, airplanes, etc.; PORTABLE tools, accessories, appliances.



A FACT-FOLDER FOR YOUR FILES.

Gives dimensions, tolerances, etc., on both COMMERCIAL and SPECIFICATION GRADES of rolled Magnesium alloy plate and sheet; also comparison tables with other metals on weights, strength and stiffness, etc. Write B&P today to send you this folder.

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INCORPORATED
Pioneer Magnesium Fabricators; Plate and Sheet Rolled from Magnesium Ingot

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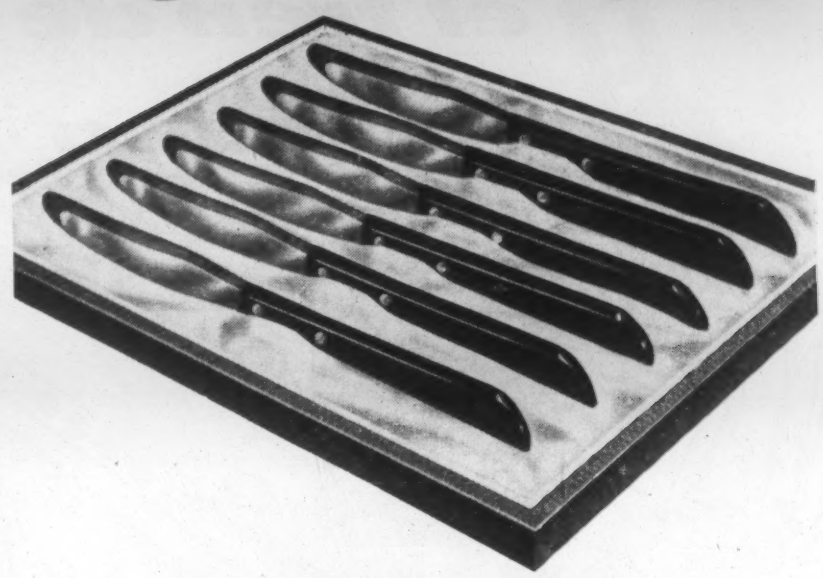
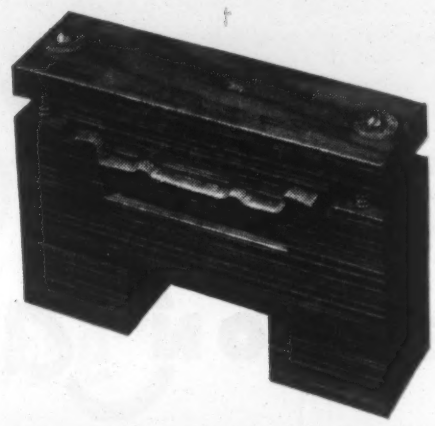
Formica



STRATA-WOOD



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SPANIARDS marvel at these Talgos that flash by on the Madrid to San Sebastian run. Developed by Spanish and United States designers, built by American Car & Foundry Company, the Talgos are more than streamliners. They are an entirely new concept in railroading! The economical, light-weight Talgos hug the rails, safely rounding curves at 80 to 90 MPH, reaching 130 MPH on the straight-a-ways. And *all* the alloy castings in these remarkable trains are Lebanon CIRCLE Ⓛ . . . 22 for each train*.

In programs requiring creative effort you'll find Lebanon engineers and metallurgists working directly with the designers to produce castings with outstanding characteristics. Such a program created *the Talgo . . . el tren de mañana!*

See—STEEL WITH A THOUSAND QUALITIES—37 min., full color sound film on the making of steel castings. For information write: Dept. D, Lebanon Steel Foundry.

*Made of CIRCLE Ⓛ 205, a light-weight, strong and tough alloy. Typical castings are illustrated above.

LEBANON Castings

CARBON, SPECIAL ALLOY AND STAINLESS STEEL

CIRCLE L

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New Materials and Equipment

work on road machinery parts, gears, pinion teeth, pump housings, shafts, sprockets, ship hawse pipes, and so forth.

Although the type of material involved and the welding conditions can greatly affect the hardness of the deposited metal, generally the hardness will be approximately 250 Brinell as welded and it will flame harden to about 350 Brinell.

The new G-E electrode is color marked by a brown end and a white spot. It utilizes alternating or direct current, and is manufactured in 1/8 to 1/4 in. sizes.

Corrosion Resistant Roller Applied Metal Coatings

A recently developed addition to the Vinsynite group of corrosion-resistant metal coatings has been announced by *Thompson & Co.*, 1085 Allegheny Ave., Oakmont, Penna. Designated as Vinsynite FS-3, the new product is a stable-type treatment formulated especially for roller coating on ferrous metals.

When baked as recommended the coating provides outstanding adhesion on ferrous metals and excellent resistance to all types of exposure. It is intended for use under top coats, but will itself protect surfaces for short periods of time. In effect, it chemically pretreats the metal and covers it with a thin vinyl primer film in one operation.

New Plastics for Industrial Applications

Three new rubber and plastic materials, Ace-Flex, Ace-Riviclor and Lur-Ace, for chemical, electrical and mechanical applications have been developed by the *American Hard Rubber Co.*, 93 Worth St., New York.

Ace-Flex, a tough, flexible, lightweight plastic material is said to have good electrical properties and outstanding chemical resistance. It is non-toxic, can be steam sterilized and is available as flexible tubing and sheet. This material is particularly adaptable for bottle filling machinery, laboratory service lines, hospital equipment, battery separators, and like applications.

Ace-Riviclor is an unplasticized thermoplastic which is said to incorporate exceptional chemical resistance with high

"For High-Accuracy, Long-Life Resistors we wind with D-H Electrical Alloy Wire"

...so states INSTRUMENT RESISTORS COMPANY, of Union, New Jersey, manufacturers of IN-RES-CO quality-built resistors for every electrical and electronic application

IN-RES-CO resistors are wound to meet the most critical requirements without excessive cost; standard inductive and non-inductive units are available in resistance ranges from 0.01 ohm to several megohms—with power ratings from a fraction of a watt to 10 watts. Included, are types especially suited to counter excessive humidity, fungus, space limitations, and temperature rise.

Says Instrument Resistors Company: "For 23 years, we have devoted our facilities exclusively to the development and manufacture of quality resistance components. The fact that today, with such a wealth of experience to our credit, we specify Nichrome, Karma, and D-H Manganin wire for windings, constitutes the strongest endorsement we can offer of these Driver-Harris products."

Nichrome*, Karma*, and D-H Manganin deliver top-level performance—their characteristic electrical and physical properties remaining unchanged even under exceptionally exacting operating conditions. They are ready to go to work for *you*, too—as are more than 80 other Driver-Harris alloys. Profit by consulting with us. We shall be glad to make recommendations based on your particular needs . . . and are confident we can meet your resistance requirements with D-H alloys that will assure the best possible results.

Nichrome and KARMA are produced only by

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BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

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of Electric Weld Tubing for Mechanical Use

TUBE DIAMETER *O.D. SIZE	MAXIMUM WALL		MINIMUM WALL	
	DECIMAL	B. W. GAUGE	DECIMAL	B. W. GAUGE
1/2"	.065"	16	.028"	22
5/8"	.065"	16	.028"	22
3/4"	.065"	16	.028"	22
7/8"	.083"	14	.028"	22
1"	.109"	12	.028"	22
1-1/8"	.109"	12	.028"	22
1-1/4"	.134"	10	.028"	22
1-3/8"	.134"	10	.028"	22
1-1/2"	.148"	9	.035"	20
1-5/8"	.148"	9	.035"	20
1-3/4"	.148"	9	.035"	20
1-7/8"	.165"	8	.035"	20
2"	.165"	8	.035"	20
2-1/4"	.180"	7	.035"	20
2-1/2"	.203"	6	.035"	20
2-3/4"	.203"	6	.035"	20
3"	.220"	5	.049"	18
3-1/4"	.220"	5	.049"	18
3-1/2"	.238"	4	.049"	18
3-3/4"	.238"	4	.049"	18
3-7/8"	.238"	4	.049"	18
4"	.238"	4	.049"	18
4-1/4"	.250"	3	.049"	18
4-1/2"	.250"	3	.065"	16
4-3/4"	.250"	3	.083"	14
5"	.180"	7	.083"	14
5-1/2"	.180"	7	.083"	14

*Intermediate sizes within the range indicated can also be manufactured. Please consult us for sizes not listed.

Manufacturers requiring tubing for civilian or defense production prefer "Standard's" Electric Weld Steel Tubing for many reasons! "Standard's" Electric Weld is produced in one of the most versatile and complete mills of its kind in the world. "Standard's" 33 years of specialized tubing "know-how", and monthly production of millions of feet of stainless and carbon steel tubing, in wide range of sizes and gauges, assure you of utmost satisfaction. No problem of tolerance, precision or severest application for mechanical, structural, or pressure tubing is too difficult.

STAINLESS STEEL TUBING
⅛" to 3" O.D. . . . .028 to .095 wall

ABOVE CHART COVERS ROUND CARBON STEEL TUBING . . .

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EQUIVALENT SQUARES, RECTANGULARS AND SPECIAL SHAPES ARE ALSO AVAILABLE.

New Materials and Equipment

impact strength and good fabricating characteristics. It is now being used in the chemical field for pipe, fittings, tank linings, formed and molded pump and valve parts and similar products.

Dur-Ace is a new thermoplastic, multi-polymer material with high impact strength, excellent dimensional stability and good chemical resistance, the company announces. It is said to be excellent for formed and draw-molded parts, as well as for corrosion resistant pipe, fittings and machined parts.

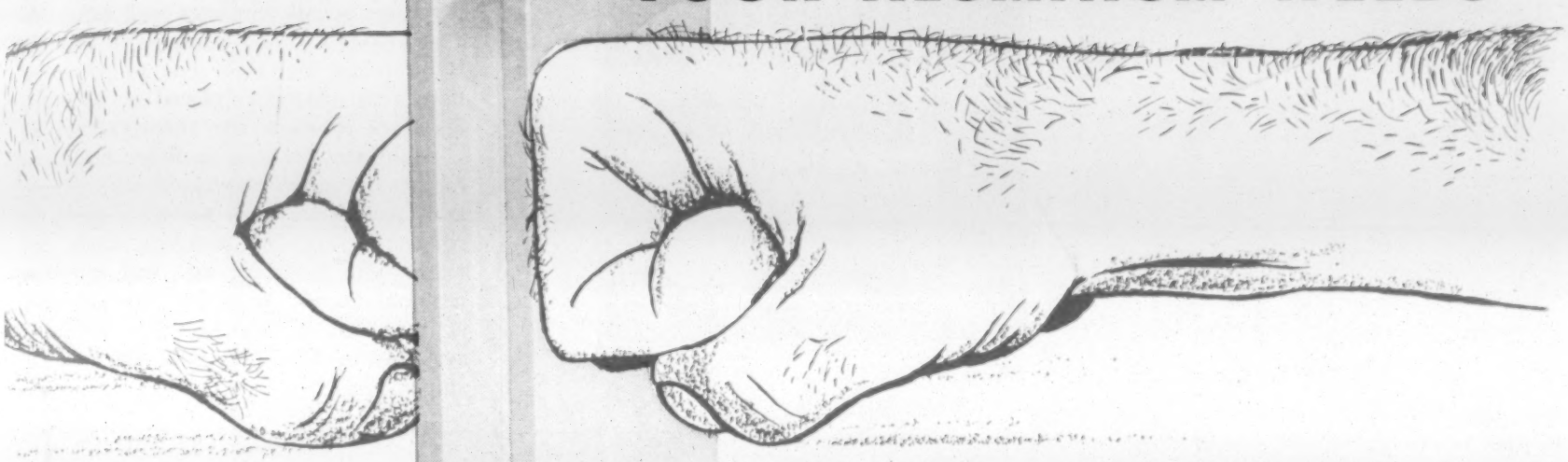
D-C Rectifier-Type Welder Gives Stable Arc

A d. c. Rectifier-type welder has been added to the line of "Sureweld" welders manufactured by the *National Cylinder Gas Co.*, 840 N. Michigan Ave., Chicago. According to NCG engineers, both the static and transient electrical characteristics of the new machine make for an unusually stable and easily handled arc. Short circuit current is high, giving sufficient drive to the arc, while output current is said to have a pronounced a.c. ripple or pulsation which tends to reduce arc blow. Voltage recovery is almost instantaneous when the arc is momentarily shorted.

A three-phase transformer supplies the a. c. power to a full wave selenium oxide type rectifier which changes this power into the d. c. current used for welding. Built integrally with the transformer is a

ALKALUME

PUTS "MUSCLES" INTO YOUR ALUMINUM WELDS

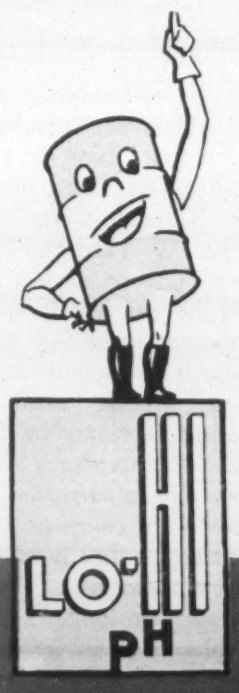


ALKALUME—another great Northwest Chemical Process—is your answer to chemically clean aluminum necessary for successful welding. This safe, simple, economical process removes soils and oxides chemically—no wire brushes or other mechanical devices to waste metal and slow production. Surface resistance is reduced to a value of 0 to 10 microhms, and a resistance of less than 20 microhms will persist for days.

The Alkalume Process assures you a reliable—day after day—production of a uniformly weldable surface—regardless of alloy. Processed stock welds fast and easily producing welds that meet specified values for penetration and shear strength. In addition, with Alkalume Processed Stock, welds are made at lower pressure. The Alkalume Process reduces the number of tip dressings, thus giving you greater tip life.

ALKALUME'S outstanding success is another fine example of Northwest's ability to get the toughest jobs done by careful blending of good chemicals and experienced service control. The complete story of Alkalume or any of Northwest's fine line of cleaning chemicals is yours for the asking. A Northwest CLEANING SPECIALIST will gladly help you with your problems.

Got a problem? Let our cleaning experts help you!



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This book tells why Forgings are used for the toughest work loads

Engineering, production and economic advantages obtainable with closed die forgings are presented in this Reference Book on Forgings. Write for a copy.

There is no substitute for the strength and toughness inherent in closed die forgings. A product fortified with the metal quality found in forgings outperforms other products. Check all the aspects of a problem part with the unrivaled economic and mechanical advantages of closed die forgings and the closed die forging process for producing parts. Double-check all parts, particularly those which are subjected to great stress and strain. Then consult a Forging Engineer about the correct combination of mechanical properties which closed die forgings can provide for your product.

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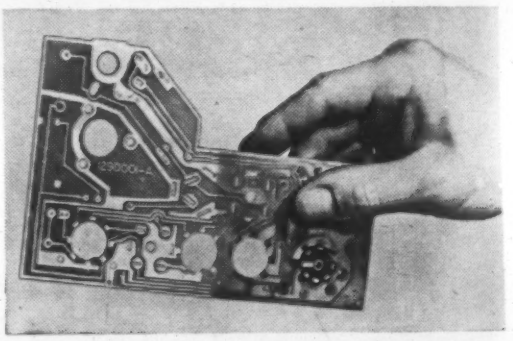
New Materials and Equipment

reactor circuit including a saturable core. A variable rheostat (or optional hand or foot operated rheostat for remote control) varies the current saturating this core and thus the output of the welder.

Cooling air, directed by baffles, is drawn in two separate paths through the rectifier stack and the transformer by a powerful fan. This is said to keep temperatures on all windings well below the 194 F (90 C) rise permissible for class B insulating materials. For added protection, a thermostat is placed on the rectifier stack to check any abnormal heating.

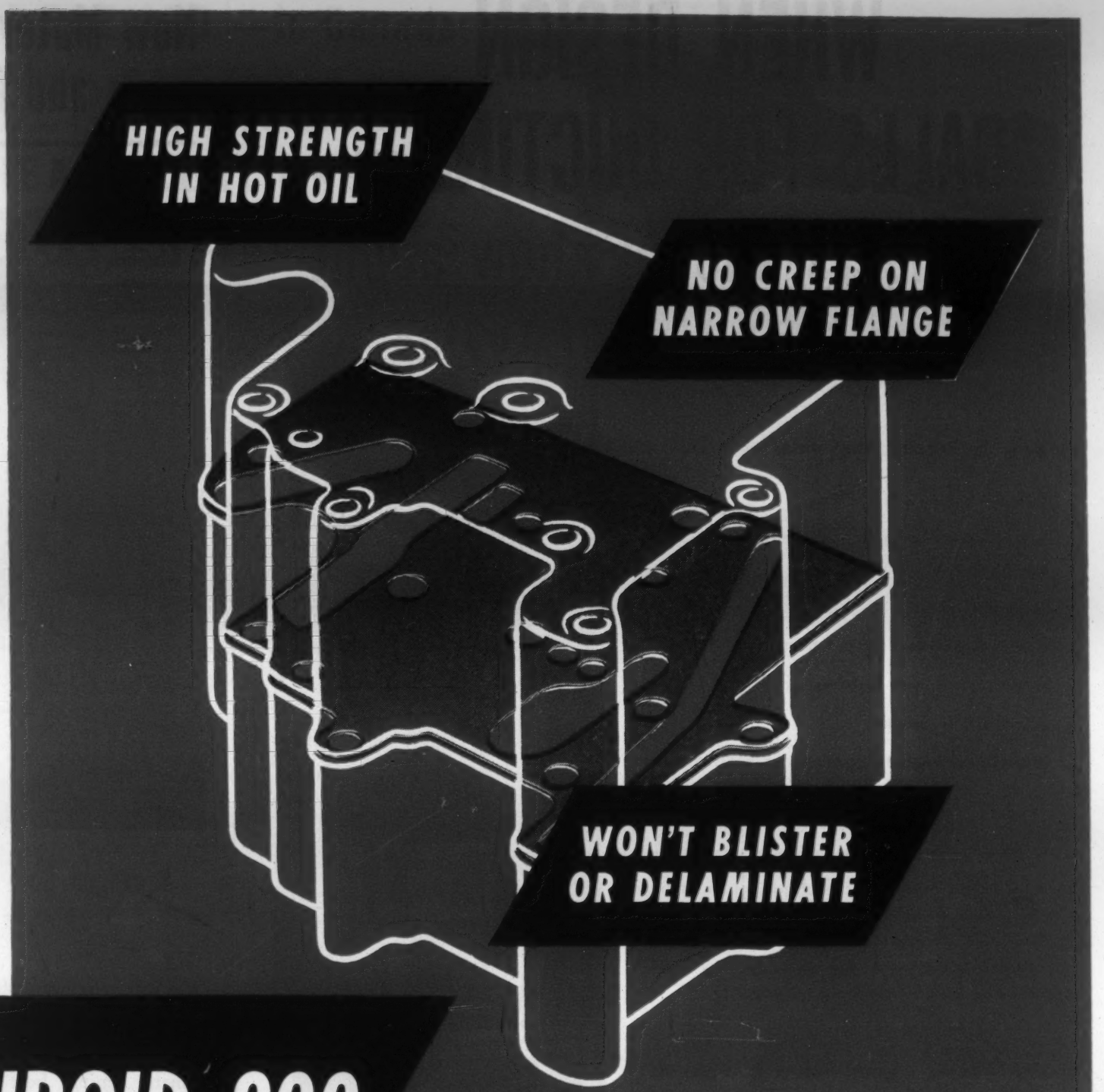
Additional features include: flush-front cabinet design with recessed control panel and receptacles for safety; "quick-disconnect" plugs on welding leads protected with fiber sleeving; and a primary terminal board, accessible through door at the back of welder. The welder is available in 100, 200, 300, 400 and 600 amp models.



Rosin Flux Insulates as It Bonds

Insulation characteristics comparable to polyethylene have been successfully combined with extreme fast "take" in a newly developed rosin flux, according to an announcement from *London Chemical Co., Inc., Dept. M6,* 325 W. 32nd St., Chicago 16. The flux is said to be devoid of any free acid and to be completely non-corrosive. These features meet two particularly important needs in present electronic applications: fast fluxing action and smooth even coating necessary in the dip tinning of printed circuits; and, elimination of breakdown due to corrosion in the soldering of delicate uhf components. Additionally, the new rosin flux is unusually resistant to high temperatures. Thus, its ability to withstand prolonged applications of heat enables it to solder through badly oxidized copper surfaces and to solder hard-to-bond metals and alloys such as cadmium, nickel and nichrome steel.

Known as Lonco Insulating Rosin Flux, the new product has undergone considerable testing under actual operation conditions. Insulating characteristics, both in the raw state and after soldering, have been thoroughly demonstrated in conduc-



DUROID 900 IS A GASKET MATERIAL YOU SHOULD TEST RIGHT AWAY

If you put machined surfaces together, you will want to check the improved sealing possible with DUROID 900. Here's a material that gives you compressibility throughout its structure . . . excellent recovery with little torque loss . . . high tensile strength in hot oil. And DUROID 900 won't weaken or harden under pressure in hot oil. It won't blister, delaminate or develop pinholes. In fact, DUROID 900 won't do any of the things you don't want a gasket to do.

Check these facts yourself. We invite rigorous testing. Write now for test data and samples to Dept. M, Rogers Corporation, Manchester, Connecticut.

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Established in 1832

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DUROIDS	ELECTRICAL INSULATION	PLASTICS	SHOE MATERIALS
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WHEN DESIGN CALLS FOR DUCTING—

engineers should know about

FLEXIBLE'S LINE OF TUBING

Every advantage you want:

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- Long life
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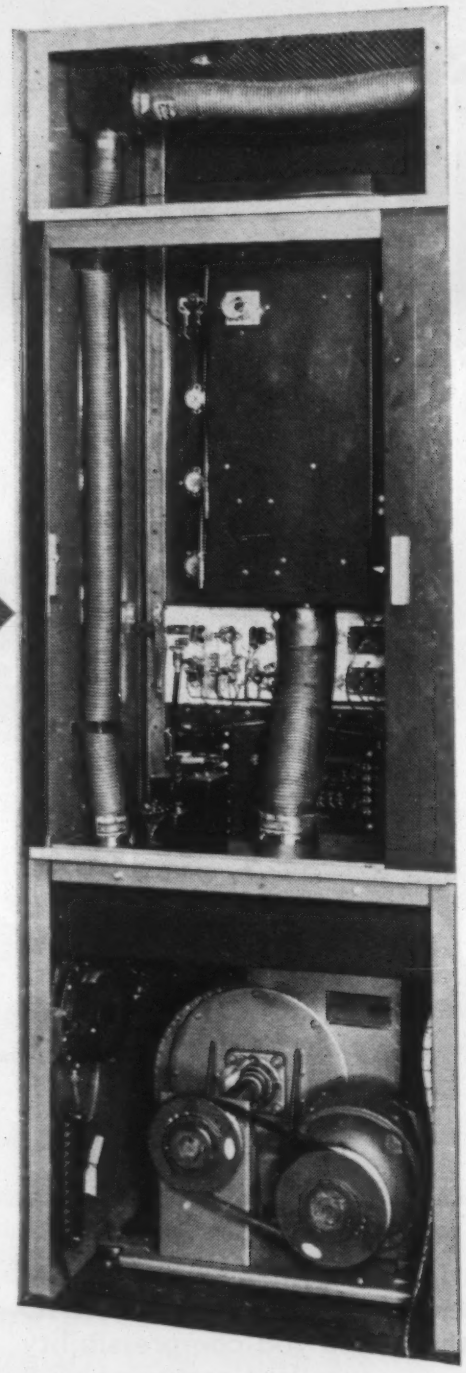
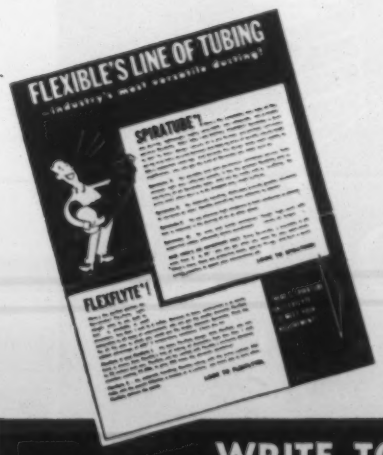
- Extra strong yet lightweight
- Abrasion resistant
- Withstand high temperatures or pressures



Flexflyte application in air cooling system of new RCA television transmitter. A primary reason why Flexflyte was chosen for this job: "Turbulences and friction losses within the tube are very small" *compared to others that were tested.*

You're missing a good bet, if you haven't discovered the many advantages of Flexible's complete line of tubing for all ducting systems. This new-type flexible ducting is available in sizes from less than 1 inch to 30" with special fabrics and coatings engineered to special needs. Our staff of field engineers is ready to help you with your flexible ducting application.



Flexible Tubing CORPORATION

Guilford, Connecticut Pasadena 1, California

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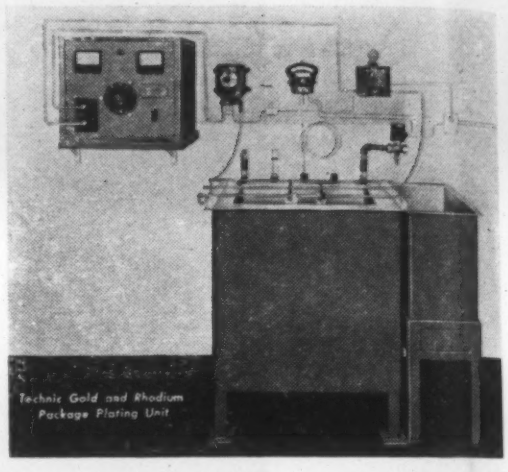
tivity, power factor and "Q" factor tests. Laboratory and field tests, conducted over a 6-month period, revealed no evidence of corrosion. The flux does not harden, crystallize, or precipitate under prolonged storage or exposure to air.



Packaged Gold and Rhodium Plating Unit

A complete, fully controlled package unit for precision plating of gold and rhodium is now available at *Technic, Inc.*, 39 Snow St., Providence, R. I. The company states that the unit incorporates automatic timing, heat control, individual power source, and indicating control for metal replenishment, with a 40 gal capacity.

The company also offers standardized soluble gold and rhodium for use with this unit. Full engineering service is available from the company.

Glass Cloth Insulation Provides Increased Strength

The Mica Insulator Co., Schenectady, N. Y., has announced the development of a new Class H silicone rubber coated glass cloth insulation, in both electrical and mechanical grades, for which they claim an unusually high dielectric strength and increased tensile strength.

The company states that both the electrical grade, E-944, and the mechanical grade, E-959, have a dielectric strength approximately twice that required by military specification MIL-C-2194A which requires the material to withstand at least 500 volts per mil after conditioning of 96 hr at 80 F and 96% relative humidity. Both grades also possess excellent bend-

AT A. V. ROE, LTD.—in Canada

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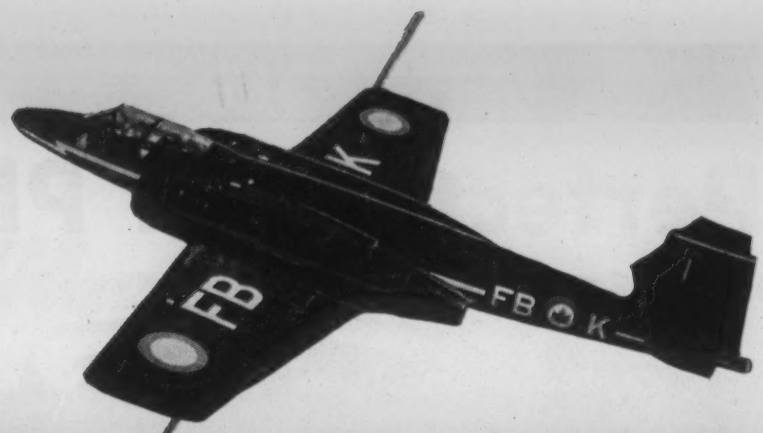
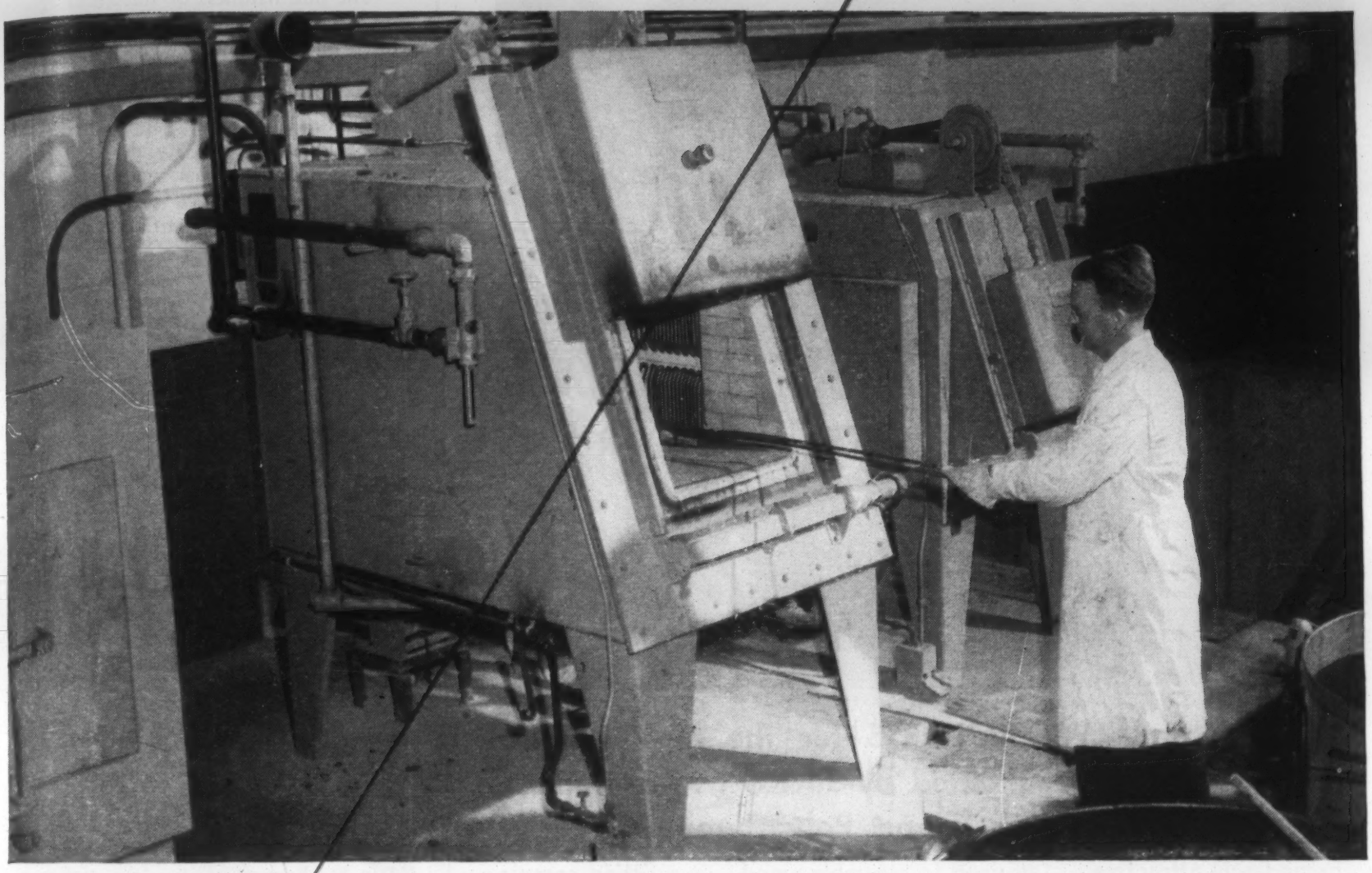
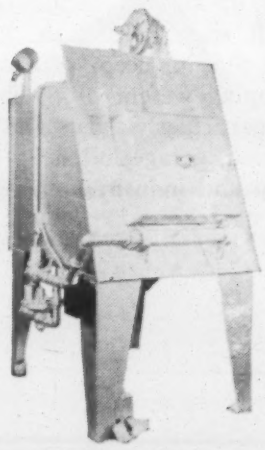
HEAT TREAT ORENDA TURBOJET ENGINE PARTS





In Canada, too . . . when production depends on precise heat treating, production men depend on Lindberg Furnaces



Proof of this is the fact that A. V. Roe (Canada) Ltd., in their new multi-million dollar aircraft plant, use Lindberg furnaces to heat treat parts for the world famous Orenda Turbojet engines.

Lindberg toolroom pre-heat and high speed Hydryzing furnaces... plus a toolroom Cyclone tempering furnace harden and temper stub shafts for the Orenda engine.

And a large box type production Hydryzer heat treats ten-stage rotor discs.

Lindberg Furnaces can solve your heat treating problem, too, from the touchiest tool and die job . . . to huge production jobs involving the hardening or tempering of tons of work daily. For descriptive literature contact your nearest Lindberg office.

Bulletin *96hs* covers the type of furnaces used in the A. V. Roe plant

LINDBERG FURNACES

Lindberg Engineering Company, 2451 West Hubbard Street, Chicago 12, Illinois

Write MW 1501 on the Inquiry Card for more information.

Perfection in Plastics

HOUSING and LEG SUPPORTS for the new Admiral Moisture Conditioner molded by SINKO . . . of Koppers MC-309 High Impact Polyestyrene

Exceedingly attractive . . . grained to resemble wood . . . a fitting complement to the most richly furnished living room.

And in addition to good looks, both the housing and leg supports offer maximum resistance to impact, moisture, and heat; highly important requirements in an appliance such as this.

You'll find the SINKO name synonymous with Perfection in Plastics . . . that is why we are today serving many leading manufacturers such as Admiral on their needs in molded plastics.

We mold all Thermoplastics including Nylon, in sizes from 4 to 60 ounce; and have the experience and know-how to offer you expert guidance on your particular requirements.

Contact us just as soon as you have a molding problem . . . we welcome your inquiries!

Sinko **SINKO MFG. & TOOL CO.**
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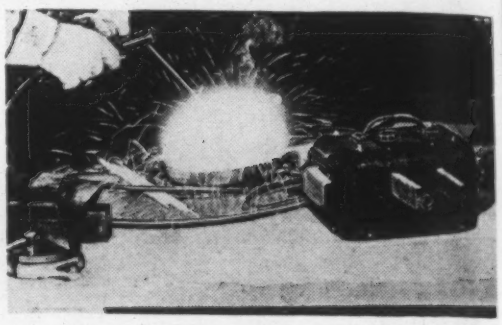
RICHARD P. VALLEE—2302 W. Clybourn St.

MARION, IND.
SAUL GANZ—4th & Branson St.

New Materials and Equipment

ing qualities due to a high tensile strength. Samples, bent and creased, show good resistance to tearing.

The film hardness or surface toughness of the mechanical grade is claimed to be three or four times as great as previous rubber coatings. Tensile strength on specimens 0.015 in. thick is 350 lb per in. of width. The moisture absorption is said to be low, and tests for dry heat resistance, run in accordance with specification AMS-3315A, show no cracks, decomposition, softening or surface tackiness.



New Portable Electric Arc Welder

A lightweight, portable electric arc welder, 110/220 a.c. with a heat range of 15 to 200 amp, has been put on the market by the *Royal Equipment Co.*, 906 Main St., Burbank, Calif. It is said to be a versatile, all-purpose, all-position welder for welding, brazing, soldering, cutting or preheating, using either the metallic or carbon arc process.

The Royal Arc uses electrodes from 3/64, in. up to and including 5/32 in. Its overall size is 10½ in. long, 7 in. wide and 6¼ in. deep, with an approximate shipping weight of 65 lb.

It is particularly adaptable to farm, shop, station, garage, oil field, mine, logging camp and industrial plant, the manufacturer states.

Compound for Pickling Solutions

A new powdered product, "Actane 33", which will, in many cases, replace hydrofluoric acid has been developed by *Enthone, Inc.*, 442 Elm St., New Haven. The manufacturer recommends it for use in acid pickles in plating cycles to remove siliceous films.

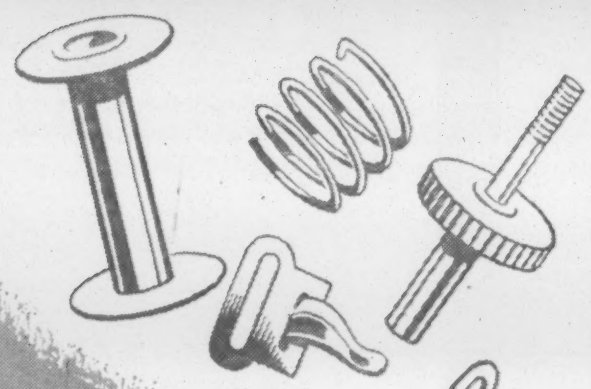
Actane 33 can be used in combination with sulfuric acid to remove silica, sand

Blacken

copper, zinc, steel

the SURE way with . . . ENTHONE

Ebonols*



Enthone, with years of experience, has accumulated a storehouse of information on the right way to blacken metals. This knowledge is always available to our customers through our Service Department.

EBONOL "S" Processes for blackening steel to produce jet-black oxide coatings. Simple and economical to operate. Operating temperatures: EBONOL "S", 285-290°F., EBONOL "S-30", 295-305°F.

EBONOL "C" The quality black for copper and brass that meets all military specifications.

EBONOL "Z" A durable, deep, rich finish for zinc plate or zinc alloy castings. Dull or glossy oxide black coatings are formed in from 5 to 10 minutes at 160-180°F.

EBONOL "Z-80" A blackening process for zinc and zinc base alloys. Operates at room temperature.

WRITE US FOR ANY NEEDED INFORMATION OR ADVICE ON ANY BLACKENING PROBLEMS

*REG. TRADEMARK

U.S. PATENT NOS. 2,364,993. 2,460,896. 2,460,898. 2,481,854.

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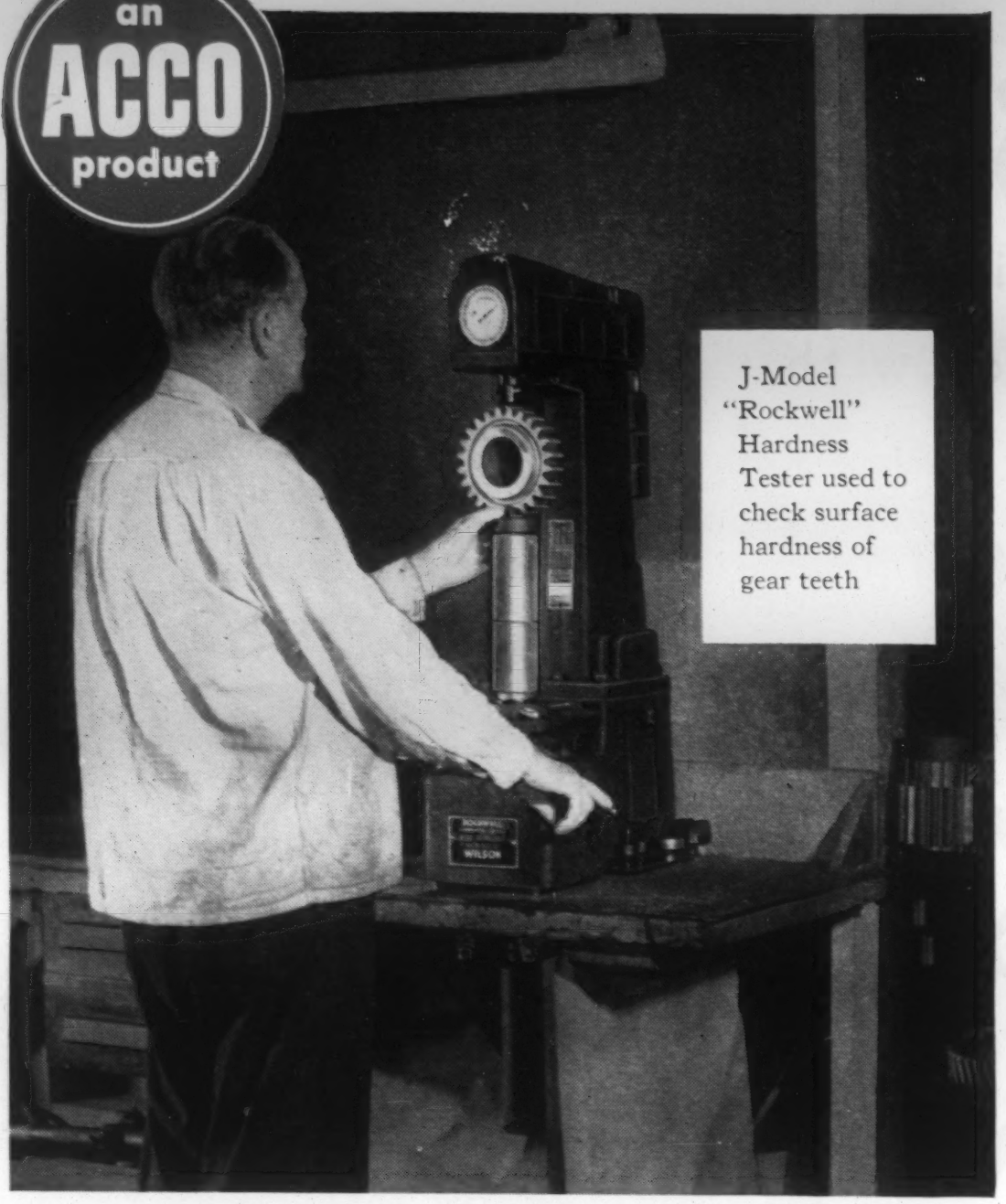

J-Model "Rockwell" Hardness Tester used to check surface hardness of gear teeth

How "ROCKWELL"* Hardness Testers Reduce Customer Complaints

● Surface hardening of wearing parts makes them last longer but it is a job requiring skill and precision. The eye cannot detect inaccuracies but a WILSON "ROCKWELL" hardness test leaves nothing to chance.

The WILSON "ROCKWELL" Hardness Tester is a precision instrument with totally enclosed "Zerominder" dial, gripsel clamp screw for quick change and proper seating of penetrator, conveniently grouped controls, enclosed variable speed dash pot, and standardized weights.

Regular and Superficial WILSON "ROCKWELL" Hardness Testers come in many styles with accessories for testing flats, rods, rounds, odd shapes.

There is the WILSON TUKON for micro-indentation hardness testing. Write for literature.

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WILSON MECHANICAL INSTRUMENT DIVISION
AMERICAN CHAIN & CABLE

230-E Park Avenue, New York 17, N. Y.

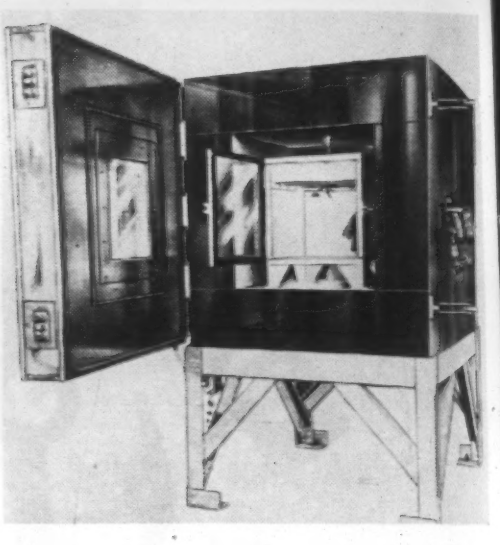
WILSON "ROCKWELL" and TUKON Hardness Testers

New Materials and Equipment

and scale from steel; with nitric acid and ferric sulfate for pickling of stainless steel; with sulfuric acid for etching of aluminum; and with nitric acid to produce white, clean surfaces. It can also replace hydrofluoric acid in titanium pickling.

Actane 33 contains soluble fluorides and penetrating and dispersing agents.

The powdered nature of this product causes fewer handling hazards than with liquid hydrofluoric acid.



Environmental Test Chamber Eliminates Magnetic Interference

A completely non-magnetic chamber has been designed by the *Bowser Technical Refrigeration Co.*, Terryville, Conn., which, the company states, excludes all stray magnetic fields during the development testing of pure metals to determine effects of temperature on electrical fields.

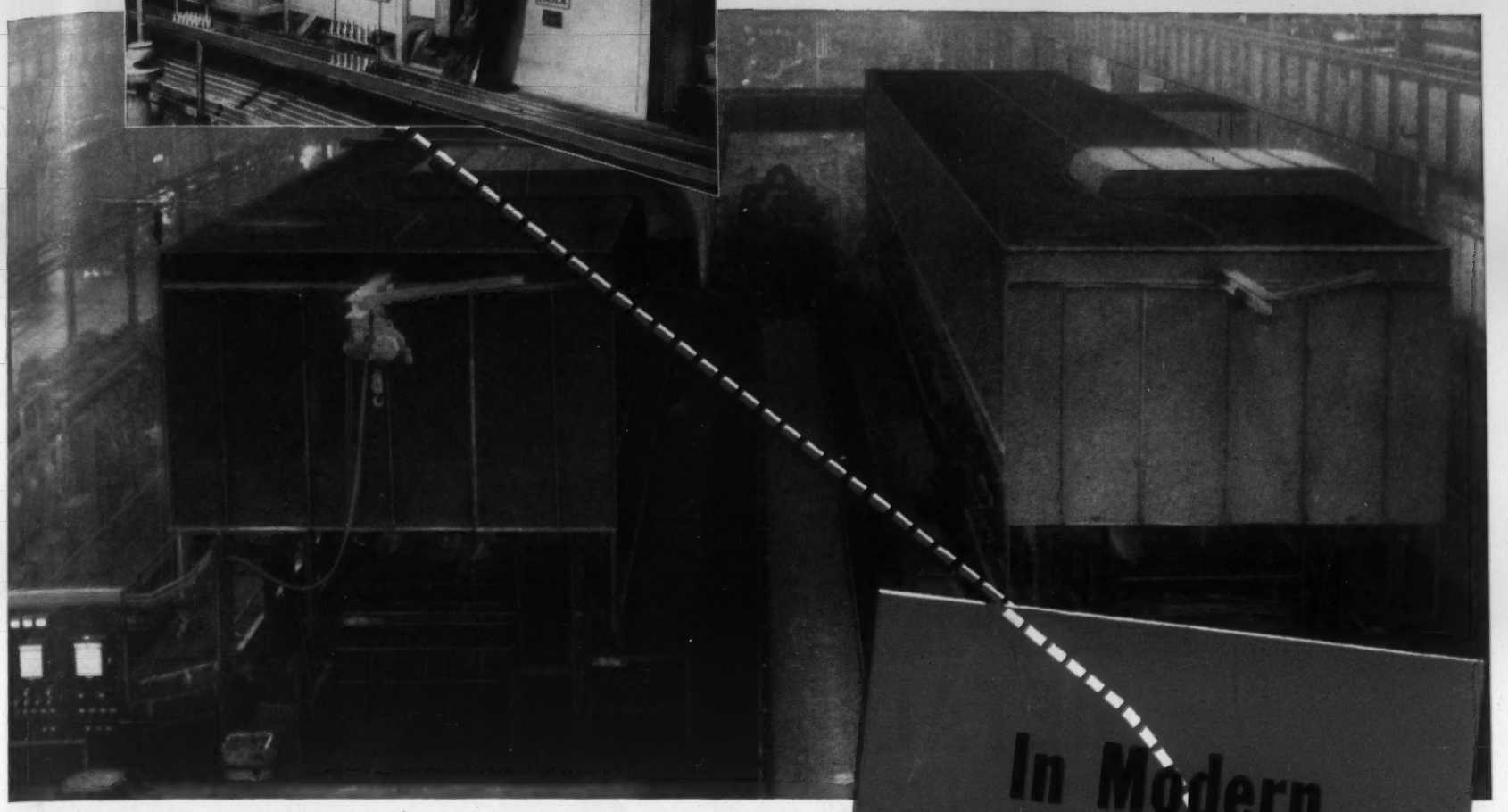
The Bowser unit contains no steel; it is constructed of brass, copper, aluminum, rubber, bakelite, glass, wood and Fiberglas. All motors and electrical components are located at least 6 ft away to eliminate effects of their electrical fields.

The unit produces any temperature from —112 F to +68 F with close temperature control. An inner chamber, thermally governed by vernier control, is said to assure holding of temperatures to ±0.1 F.

Aluminum Welding Flux

An aluminum welding flux, sufficiently active and fluid to carry the opaque slag blanket off the weld puddle and allow the operator to see the work has been

From the batch type installation at the left martempering base detonator fuses, to the huge mechanized furnaces austempering automobile bumpers illustrated below, Ajax Electric Salt Bath Furnaces are replacing old-style quench and temper methods for a wide variety of steel products.



In Modern Heat Treating— the Trend is to MARTEMPERING and AUSTEMPERING

From ring gears to plow points . . .

From bearing races to cast iron cylinder sleeves . . .

From uniformly shaped metal parts to odd and irregular sizes . . .

Scores of installations have proved the tremendous possibilities for economy, greater speed and efficiency in martempering and austempering, because all water and oil quenches are eliminated.

Distortion is so negligible that parts can be machine finished *before* hardening. Final grinding is eliminated or materially reduced. Scale, decarb and quench cracks are eliminated. Toughness and ductility are increased. The work is done materially faster—in less floor space—with lower labor costs. Let the Ajax Metallurgical Service Laboratory prove these claims on a specimen batch of your actual parts, under actual working conditions.

Write for Ajax Bulletin 120

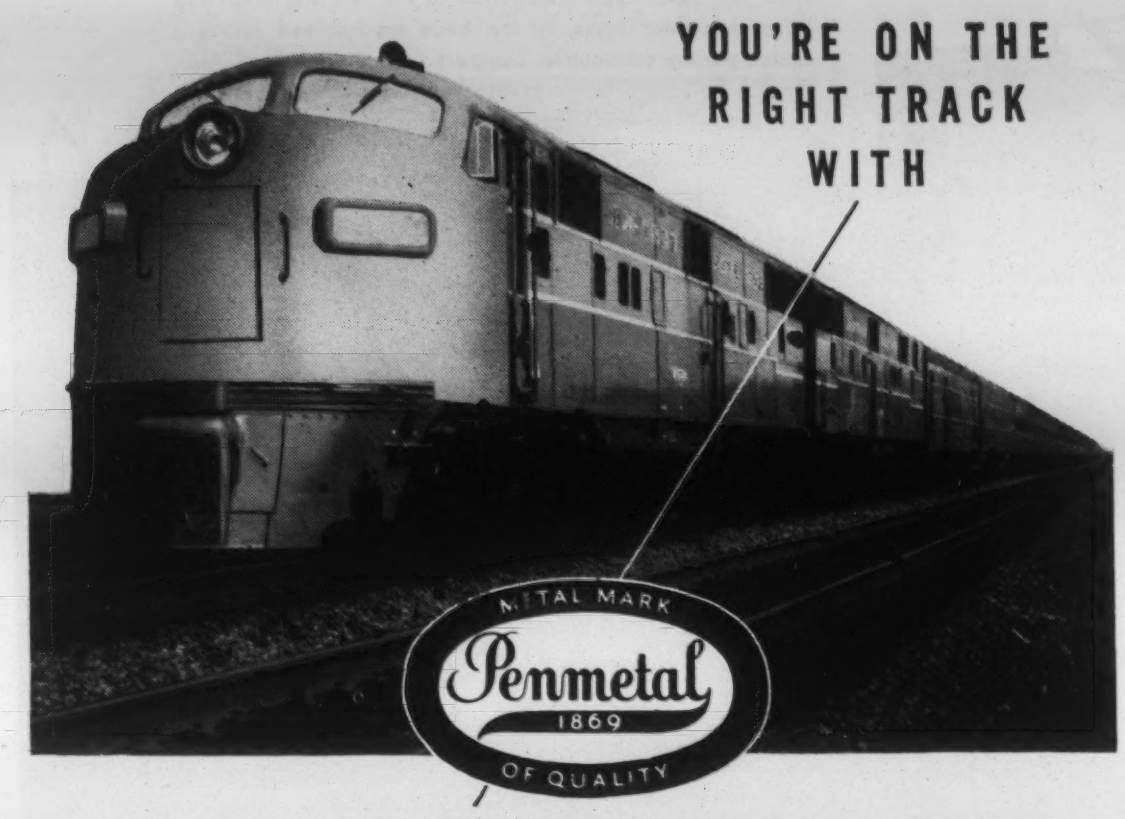
AJAX ELECTRIC COMPANY, INC.

906 Frankford Ave., Philadelphia 23, Penna.

World's largest manufacturer of electric heat treating furnaces exclusively

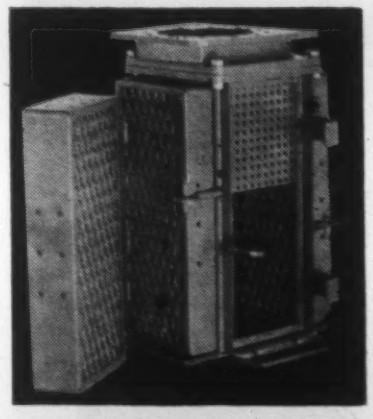
AJAX HYCLIGRIP ELECTRIC SALT BATH FURNACES

See Us at the Metal Show in Cleveland—Booth 221



EXPANDED METAL MESH

Cheapest "Diamonds" You Can Buy



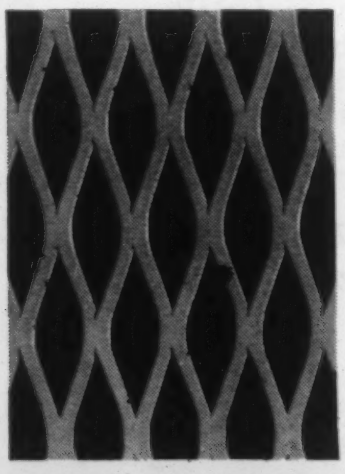
Farr Filter Adapter Assembly used extensively on freight and passenger locomotives.

1000's OF USES

Railroad Air Filters, for example: Penmetal Expanded Metal Mesh is strong, good-looking, light-weight, non-warping, fireproof. It is easily formed, shaped and welded . . . weighs as little as 10% of the solid sheet. That's why the Farr Company of Los Angeles uses Penmetal Expanded Metal Mesh in the design and construction of Far-Air Filters for Diesel Locomotives, Passenger Cars, Air Compressors and special railroad applications.

MAKES A LITTLE METAL GO A LONG WAY. Penmetal Expanded Metal Mesh is sheet metal—slit, then stretched up to 10X its original area. Resulting diamond truss pattern adds rigidity—permits free passage of heat, light, sight, sound and air. Available in corrosion-resistant metals and carbon steel. Large or small mesh, light or heavy gauge.

STANDARD EXPANDED METAL



FLATTENED EXPANDED METAL

Get the facts! They'll suggest 1000's of ideas and applications. Write for free Bulletin EM43.

PENN METAL COMPANY, INC.

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DETROIT, CHICAGO, DALLAS, LOS ANGELES, SAN FRANCISCO, SEATTLE

New Materials and Equipment

developed by *Solar Aircraft Co.*, San Diego.

Following laboratory and field tests, the manufacturer announced that the following characteristics of Type 202 flux were reported:

1. The flux starts to reduce oxides immediately upon application and continues to do so throughout the heating cycle.
2. The flux is easily removed after welding, and will not produce corrosive pitting on the parent metal.
3. The flux becomes liquid at the point in the heating cycle when the metal is ready to weld, serving as a good temperature indicator.
4. The flux is an excellent wetting agent, and is easily applied.
5. With this flux, the hotter flame of oxyacetylene can be used in aluminum welding without fear of overheating.
6. The flux can be used as a back-up material on butt or T joints to control penetration, and can also be used to eliminate the oxide notch on the back of the work.
7. The flux allows the operator to see readily the molten puddle, and no puddling stick is needed to remove oxide slag.

The manufacturer says the new Type 202 is now available to industrial and other users in 1-lb containers through welding supply dealers.

New Metal Cleaner for Vitreous Enamel Industry

The Detrex Corp., Detroit 32, announces the development of a new metal cleaner for use in the vitreous enameling industry. Detrex 63 is described as a medium-high alkaline compound containing high wetting and penetrating properties, with an exceptional ability for emulsifying large quantities of mineral oils and greases and keeping them in a state of suspension.

It was designed to provide enamelers long lasting finishes at lowest cost by meeting the following basic requirements for a metal cleaner in the enamel industry:

1. It must clean the work with no traces of soil to reduce the effectiveness of the enamel finish.
2. It must provide maximum life for economy and uniformity.
3. It must create little or no sludge in

CARBORTAM* produced by TAM*, is an effective ladle addition to:

1 promote hardenability, at low cost, in low alloy forging steel and wrought iron.

2 provide ductility in steel castings.

AND NOW...

3 recent production tests indicate successful use for Boron additions in all types of Boron steels.

Get complete facts on the advantageous use and economy of ***improved*** Carbortam in your operations by writing our N.Y.C. office.

*TAM and CARBORTAM are registered trademarks

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TITANIUM ALLOY MFG. DIVISION
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Quality is Work...
not just a Word

Quality is a man in overalls and canvas gloves sorting metal.
Years of experience tell him what is red brass, copper, silicon bronze,
bell metal, lead, tin; or ferrous metal to be thrown aside.

Quality is a metallurgist selecting and assembling metals to be
melted and balanced to meet the precise chemical
contents specified in dozens of alloys required by industry.

Quality is a chemist testing samples of a melt until
precise specifications are attained and he says it is time to pour.

Quality is millions of dollars invested in laboratories,
research, storage, raw materials and distribution depots,
so that Federated customers can be assured of specification
products, uniform, *every* time.

Quality is the big staff of Federated representatives
whose job is to share and solve the problems of the one-man shops
and the big foundries that are Federated's customers.

Quality is the effort to achieve perfection . . . and the resources
to apply that effort from the depths of the mine to the shipping-case
which brings non-ferrous products to your place of
business from Federated . . . Headquarters for Non-ferrous Metals.

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AMERICAN SMELTING AND REFINING COMPANY
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Federated first in the non ferrous field FMD

Aluminum and Magnesium, Babbitts, Brasses and Bronzes, Anodes,
Die Casting Metals, Lead and Lead Products, Solders, Type Metals

New Materials and Equipment

order to keep costs and maintenance time low.

4. It must contain high emulsification power.

5. It must afford low surface tension for thorough rinsing power.

6. It must provide top cleaning efficiency even under hard water conditions.

When used by vitreous enamelers, the new Detrex cleaner is particularly recommended for work requiring removal of non-pigmented drawing and stamping compounds, mineral and vegetable oils and grease, and quenching oils from ferrous parts prior to the enameling operation.

New Solder Contains Flux in Alloy

An electrical HR series of alloy paste solders containing a neutral flux in the alloy has been developed by *Fusion Engineering,* Cleveland. These solders are designed for use in transistor and diode soldering and printed circuits, in addition to general electronic applications, specifically where work is covered by Federal specifications MIL-S-6872, AN-S-62, and MIL-E-5400, the manufacturer states. The separate fluxing operations encountered with pre-forms, foil or wire are eliminated by the use of the Fusion Paste Solder Alloys.

All metals used in the alloy paste solders are said to conform to Federal specifications QQ-S-571-b, and the activated high rosin flux in the alloy prevents corrosion. Temperature ranges available extend from 220 to 650 F to meet all requirements, including bi-temperature soldering.

With the incorporation of the flux in the alloy with the solder, the paste can be pre-applied and heated semi-automatically or automatically by unskilled help, which is said to result in material labor savings.

The company states it will make recom-

The Alchemy of Light

Far surpassing in importance the transmutation of metals, for which the ancient alchemists strove, is the modern transformation of light to a useful force.

Television, like so many other great advances, rests on the utilization of a basic natural law: in this case that the element selenium, when exposed to light, generates an electric current.

It's great to have an idea. It's much more wonderful to make it work. That's where we come in. Many of today's greatest ideas have been made to work only by inclusion of the correct Sirvene part.

Sirvene is not a single product or formula. Highly versatile, it is the "personalized" compound of oil resistant elastomers (synthetic rubber), and the special design of the molded flexible part essential to the satisfactory operation of a critical mechanism. Such as yours.

The time to call in our experienced Sirvene engineers is when your project is on the drawing board. Then we can work with you to develop the Sirvene unit that will possess the exact degree of flexibility or hardness, with correct resistance to extreme temperatures, pressures, fluids, gases, abrasion, and wear. This part may also need to be bonded to other materials.

Once the correct formula is developed, Chicago Rawhide produces, in quantity, the resulting custom-built part, under strict laboratory control.

The monograph "Engineering with Sirvene" will be sent you free on request. Your correspondence is cordially invited.

Sirvene products include diaphragms, boots, gaskets, oil seals, washers, packings and similar molded parts.

CHICAGO RAWHIDE MANUFACTURING CO.

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IRIDITE®

for on any of these metals Iridite gives you a high performance finish at a low cost from a simple chemical dip.

IF YOU WANT HIGH CORROSION RESISTANCE, you'll find an Iridite that will meet any military or civilian specifications for chromate finishing.

IF PAINT ADHERENCE IS IMPORTANT, you'll find Iridite prevents underfilm corrosion and soap formation.

OR, FOR BRIGHT, DECORATIVE FINISHES—

investigate zinc plate and Iridite (Bright) for a chrome-like decorative finish with more corrosion protection than conventional chrome plating . . . or Iridite (Metcote) as a treatment for copper that eliminates the need for buffing in the copper-chrome system; produces a sparkling bright finish!

Write for literature and send us samples for test processing. See "Plating Supplies" in your classified telephone directory or write direct.

Iridite is approved under government specifications.

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Manufacturers of Iridite Finishes for Corrosion Protection and Paint Systems on Non-Ferrous Metals; ARP Plating Brighteners.
West Coast Licensee: L. H. BUTCHER COMPANY

New Materials and Equipment

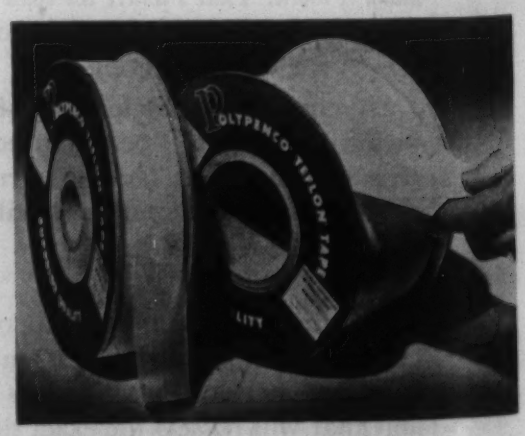
mendations for methods of application if readers will submit prints of parts with all relevent details.

One-Stage Cleaner Prepares Metal for Painting

Klem Chemicals, Inc., 14401 Lanson Ave., Dearborn, Mich., has developed a non-toxic, one-stage phosphate cleaner for all types of metals which, they claim, will remove, in 60 sec, all traces of oil, dirt, rust and tarnish, leaving a light, uniform phosphate coating on the surface to improve paint adhesion.

The cleaner, known as Minit-Kote, is particularly designed for use in spray type washers at temperatures of 160 to 180 F at a concentration 0.25 to 2% by volume.

Minit-Kote can also be used instead of an alkali rinse in spray gun or steam cleaning equipment at an even lower concentration, the company states. Since it does not percipitate hard water salts, it can be diluted with any type of water.



Electrical Tape Resists Deterioration

The Polymer Corp., Reading, Penna., now has available a Teflon insulation tape which, the company states, is chemically inert and completely unaffected by weather conditions, temperature flunctuations and exposure to oils and greases. It is particularly adaptable for insulating motors, generators, transformers, and coils, since it is said to retain excellent

Can you predict your vinyl's performance?

We both know that vinyl product performance depends pretty much on *plasticizer* performance.

And we at Naugatuck—since we make and supply fine vinyl resins and compounds—know what you expect and need from your plasticizers. We ourselves are using them every day, testing, evaluating, trying for the best possible results.

We offer you a line of *thoroughly proven* plasticizers we feel you can rely on to meet your most demanding requirements.

for • UNIFORMITY • LOW ACIDITY • COMPATIBILITY • LOW VOLATILITY • FLAME RESISTANCE • LOW TEMPERATURE FLEXIBILITY • COLOR AND HEAT STABILITY • ALMOST *ANY* PLASTICIZER NEED

Make sure you're giving your vinyl products every possible advantage. Send for free samples of any of the following.

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Naugatuck Chemical
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- ☐ DiButyl Phthalate
- ☐ DiIsoOctyl Phthalate
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Naugatuck, Conn.

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Philadelphia • IN CANADA: Naugatuck Chemicals, Elmira, Ontario

It is one of the most economical sources of hydrogen and nitrogen for metallurgical uses.

You get 4500 cubic feet of mixed gases when one 100-pound cylinder of Barrett® Brand Anhydrous Ammonia is dissociated at normal temperature and pressure. Or approximately 3375 cubic feet of hydrogen and 1125 cubic feet of nitrogen.

Properly working cylinder valves insure trouble-free use when cylinders reach you.

Fast delivery service of ammonia in 150, 100 and 50-pound cylinders. Coast-to-coast stock points and an adequate supply of cylinders make this possible.

Free technical help from men specially trained in the use of anhydrous ammonia for metal treating.

●

All of this adds up to greater savings, better service and better performance for you. Write for your free copy of a new booklet, "Guide for the Use of BARRETT® Brand Anhydrous Ammonia in Cylinders."

Always specify Barrett® Brand Anhydrous Ammonia—the brand with the bright green cylinder caps.

NITROGEN DIVISION ALLIED CHEMICAL

Nitrogen Division
ALLIED CHEMICAL & DYE CORPORATION
40 RECTOR STREET, NEW YORK 6, N. Y.

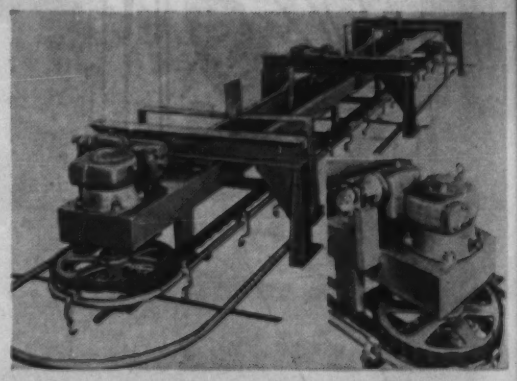
New Materials and Equipment

electrical properties over a wide range of frequencies and temperatures.

The "Polypenco" Teflon tape will not deteriorate under continuous service at 482-518 F (250-270 C), the manufacturer claims, and because of its high elongation value, it fits tightly over sharp bends, corners and other hard-to-insulate surfaces.

Applications for this tape are found in the electronic, aircraft and power industries as well as the electrical industry.

"Polypenco" Teflon tape is available in thicknesses of 0.002 to 0.125 in. and in widths of 1 to 12 in. in 1.4 in. gradations. Other sizes are available at special request.



New "Packaged" Electroplating System

A new, "packaged", semi-automatic electroplating system which is said to greatly increase plating production and quality has been designed by *Wagner Brothers, Inc.*, 422 Midland, Detroit 3.

The system may be altered for different jobs by shifting "pusher shoes" to the desired spacing; or spacing to any dimension in 2 in. increments can be accomplished by removing pusher shoes. The variable speed control and drive are combined in one unit which may be replaced by removing a few hold-down bolts. Standard v-belts are used for drive and agitating mechanisms, and hazards of drip, moisture and corrosion are said to be eliminated by the totally enclosed ball-bearing motor. The driving sprocket shaft turns on three bearings, two in the speed reducer, one in the frame. The design of the Wagner "semi" permits loading at any point and the anode bar is formed equidistant from the cathode at ends as well as sides, producing plating that is uniform and uninterrupted. The packaged system, including tank to

20% STEEL SAVINGS

WITH AJAX-NORTHRUP INDUCTION HEAT FOR *Forgings*

Ajax-Northrup induction heat works so fast there's no time for scale to form. This not only saves steel, but gives longer die life, closer tolerances, a smoother finish and fewer rejects. This all adds up to steel saving—as much as 20% for some work.

Ajax-Northrup heaters are available to heat all or any part of a billet, with precise temperature and gradient control, and with any desired type of automatic timing and handling devices. They fit right into your production line, take up little floor space, are clean, quiet, and easy to live with.

Our 37 years of induction heating experience can help you produce better forgings, cut costs, and save steel. Write us today.

152

Since 1916

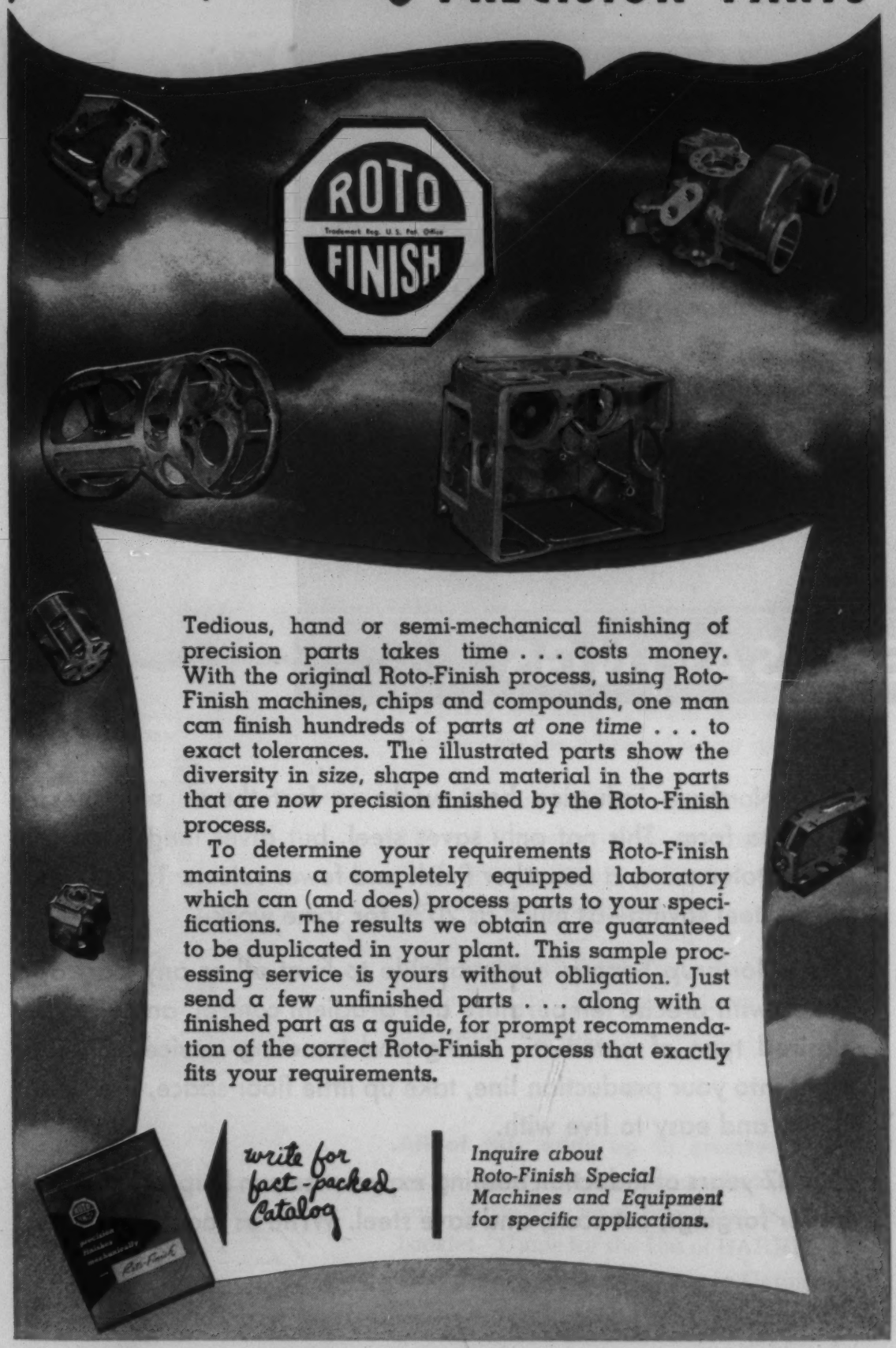
AJAX ELECTROTHERMIC CORPORATION
Ajax Park, Trenton 5, New Jersey

Associated Companies
AJAX ELECTROMETALLURGICAL CORP.
AJAX ELECTRIC FURNACE CORPORATION
AJAX ELECTRIC COMPANY, INC.
AJAX ENGINEERING CORPORATION

AJAX NORTHRUP

INDUCTION HEATING AND MELTING

THE SKY'S THE LIMIT IN SAVINGS WHEN YOU *Roto-Finish* PRECISION PARTS



Tedious, hand or semi-mechanical finishing of precision parts takes time . . . costs money. With the original Roto-Finish process, using Roto-Finish machines, chips and compounds, one man can finish hundreds of parts *at one time* . . . to exact tolerances. The illustrated parts show the diversity in *size*, shape and material in the parts that are *now* precision finished by the Roto-Finish process.

To determine your requirements Roto-Finish maintains a completely equipped laboratory which can (and does) process parts to your specifications. The results we obtain are guaranteed to be duplicated in your plant. This sample processing service is yours without obligation. Just send a few unfinished parts . . . along with a finished part as a guide, for prompt recommendation of the correct Roto-Finish process that exactly fits your requirements.

write for fact-packed Catalog

Inquire about Roto-Finish Special Machines and Equipment for specific applications.

Roto-Finish COMPANY

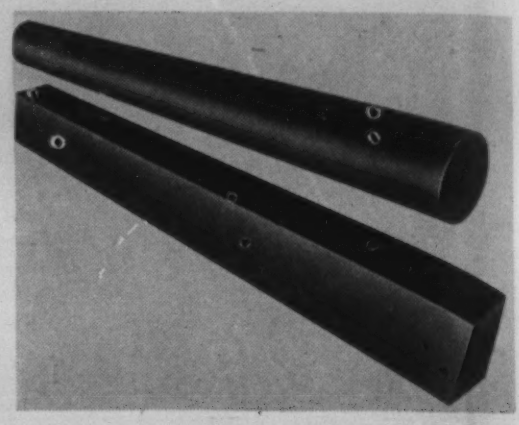
associated with The Sturgis Products Co.
3726 MILHAM ROAD, KALAMAZOO, MICH.

P. O. Box 988—
Phone 3-5578

FOREIGN REPRESENTATIVES: CANADA — Windsor — Roto-Finish Canada Limited • ENGLAND — London — Roto-Finish Limited — 39 Park Street — Mayfair • AUSTRALIA — Melbourne — A. Flavell Pty, Ltd. • HOLLAND — Delft — N. V. Roto-Finish Maatschappij — Rotterdamse — WEG 370A • AUSTRIA, GERMANY, SWITZERLAND — Frankfurt a.M. — Metallgesellschaft A.G., Germany • ITALY — Milan — Societa Roto-Finish a R.L. — Sesto S. Giovanni — Viale E. Marelli 31 • FRANCE — Paris — Societe Roto-Finish, 70 rue de la Republique-Puteaux (Seine) • BRAZIL — Rio de Janeiro — Commercial E. Industrial de Formos Werco, Ltds.

New Materials and Equipment

standard or user's specifications, is insulated at critical points and wired ready for installation.



Graphite Rods For Salt Bath Rectification

Graphite rods for automatic rectification of electric salt bath furnaces for high-speed steel heat treating are now available at the *Stackpole Carbon Co.*, St. Marys, Pa. Decarburization of the work is avoided, electrode life is said to be materially prolonged and renewal of the salt bath is less frequently necessary. The manufacturer states that the graphite rods do not cause any sludge formation, resulting in better bath circulation and faster heating.

Stackpole HC-1 grade graphite rods for this purpose are supplied in diameters ranging from 1½ to 2½ in. and lengths to 30 in. Bars 2 in. square up to 36 in. long are also available. A wider variety of sizes and shapes can be supplied on special order.

A copy of the new Stackpole Catalog 40A describing these and other carbon and graphite specialties may be obtained on letterhead request to the manufacturer.

Compound Speeds Electrolytic Stripping of Defective Plate

A new acidic compound has been marketed which is designed to serve as the electrolyte in the electrolytic stripping of defective copper, nickel and chromium plate from zinc base die cast-

Crucible Alnico Magnets help ruggedize

Roller-Smith Instruments

13% smaller—same magnetic strength

When the Roller-Smith Corporation decided to ruggedize their electrical instruments to meet Military Specifications, they discovered that they needed a smaller permanent magnet — one that would do the same job as the old one they were using.

They called on Crucible's technical service for assistance. In short order, Roller-Smith's objective was attained. For through improved design, and better quality control in production, Crucible developed an alnico magnet that was 13.5% smaller and lighter than the previous one . . . but with the same magnetic strength.

The Roller-Smith story is typical of the many cases solved with Crucible Alnico Magnets, because Crucible magnets have the highest gap flux per unit of weight of any on the market. Crucible has been the leading producer of Alnico Permanent Magnets since the industry started. When you have a magnet problem, call on Crucible.

CRUCIBLE first name in special purpose steels

53 years of *Fine* steelmaking

PERMANENT ALNICO MAGNETS

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

STAINLESS • REX HIGH SPEED • TOOL • ALLOY • MACHINERY • SPECIAL PURPOSE STEELS

"WHO CUT THIS 0.0006" UNDERSIZE?"

Reprinted with permission of the *American Machinist*

DO YOU NEED A

"PUTTIN'-ON-TOOL"

for salvaging undersize parts, worn tools and gages right in your own plant?

Now, with the Chromaster industrial chrome plating unit, you can restore undersize components or worn tools to exact dimensions, easily and simply, in a matter of minutes. With Chromaster, you will be able to salvage thousands of dollars worth of material you're now throwing into the scrap bin.

Here are the facts about Chromaster:

- **SIMPLE TO OPERATE**
- **NO PREVIOUS PLATING EXPERIENCE NEEDED**
- **FAST DEPOSIT RATE. .002" per hour**
- **CHEMICALLY STABLE PLATING SOLUTION**
- **LOW PLATING COST . . . only 7 mils per sq. in. .002" thick**

Now take a look at a few of the actual savings the Chromaster has made in other plants.

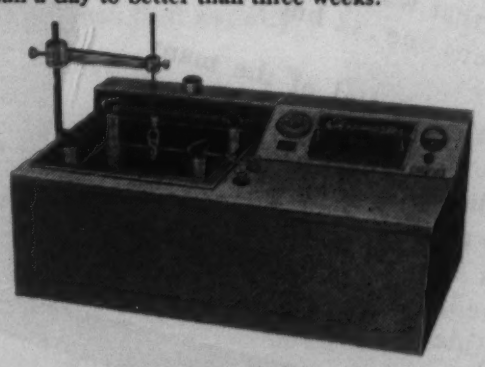
ACTUAL CHROMASTER SAVINGS

A CHICAGO TOOL COMPANY with 1500 shafts ground undersize used a Chromaster to return them to their original size with a surface finish of greater wear resistance.

A PHILADELPHIA MANUFACTURER used Chromaster to correct an oversized cylinder bore by plating to size.

A BROOKLYN FOUNDRY saved two grinding operations and almost five hours in plating time on every component with Chromaster.

A CALIFORNIA AIRCRAFT FACTORY salvaged expensive worn-down reamers with Chromaster. The new plating increased their useful life from less than a day to better than three weeks.



A CHROMASTER FOR EVERY SHOP

Model A-20 is a 20-amp, bench-mounted unit for the gage room or tool crib; plates up to 10 sq. in.

Model A-50, 50-amp, bench-mounted unit for larger shops in plating of cutting tools. Plates up to 25 sq. in.

Model A-250, 250-amp, floor-mounted unit for production plating of small parts in greater quantities or larger parts with areas up to 125 sq. in.

Chromaster

Write for money-saving free information today A•3•3

Industrial Chrome Division
Ward Leonard Electric Co.
South Street,
Mount Vernon, N. Y.

Please send me information on industrial chrome plating with CHROMASTER.

COMPANY.....

NAME..... TITLE.....

ADDRESS.....

CITY..... ZONE..... STATE.....

New Materials and Equipment

ings. The product, Compound L-88, was developed by *Enthone Inc.*, 442 Elm St., New Haven, and is available as a ready to use solution.

In this process the defective zinc castings act as the anode in the solution at a 6 v current. If a lead lined tank is used it may serve as the cathode, and the dissolved metal will plate out on the side of the tank in a semi-adherent form, leaving the clean zinc surface with a passive film that inhibits further attack on the metal.

The temperature range of operation is from 70 to 180 F, the higher temperature producing a faster stripping action. The power source should supply a d.c. current of at least 6 v and sufficient amperage to draw at least 25 amps per sq ft for the immersed surface. For faster stripping, current densities as high as 100 amps can be employed effectively.

The solution may also be used for stripping chromium, copper and nickel from steel; however, there will be some attack on the base metal resulting in dimensional loss, though the electropolishing action will leave a brightly polished surface.

Compound L-88 is available in 5 and 13 gallon carboys and is designed for use without dilution.

New Air Operated Spot Welder

The Taylor-Winfield Corp., Warren, Ohio, has marketed a new Type EB-3 Air Operated Spot Welder which is small and compact in form, lending itself to either single operation or, in a bank or gang, to production jobs.

A welding force of either 750 lb or 1,000 lb max is obtainable by the use of an 80 psi line pressure. The actual throat depth is 8 in., and the electrode stroke is 1¾ in. max. The lower horn is 2 in. dia and vertically adjustable to 4 in., with an additional 1¼ in. vertical adjustment when the lower horn holder is inverted. The lower electrode (ejector type) is 6 in. long and 1 in. dia, with a No. 1 Morse Taper, while the upper holder is built as a permanent part of the upper terminal. Upper and lower electrodes are Code B-216, Domed Type, Class 2 Alloy with a No. 1 Morse Taper. Overall length is 1½ in.

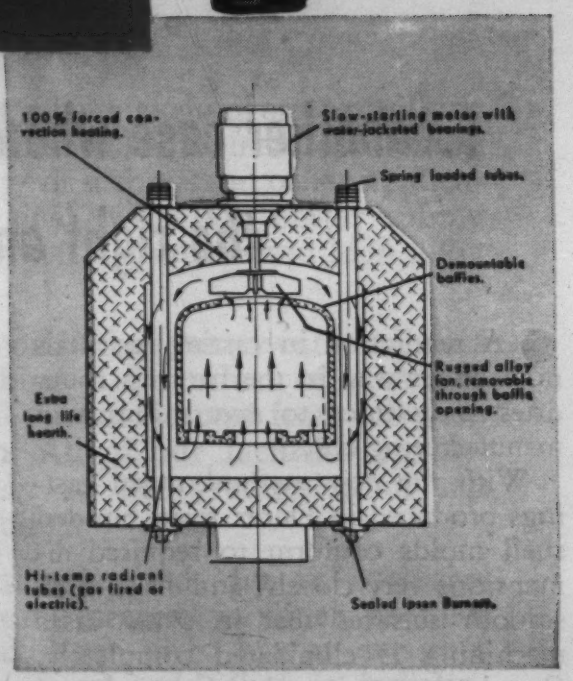
The manufacturer states that while many possible combinations of electrical controls are available, the use of synchronous-precision controls is recommended where exacting work require-

Now...

Ipsen 100% FORCED CONVECTION UNITS FOR TEMPERATURES UP TO 1850° F.

▲ *New Ipsen 400 Lb./Hr. Automatic Heat Treating Unit equipped for martempering. Straight-through operation from heat through quench, or cooling, eliminates loading delays.*

▶ *Ipsen's new radiant tube and 100% forced convection heating design. Spring-loaded tubes seal automatically. Controlled atmosphere throughout assures bright, clean, scale-free work.*



Ipsen controlled atmosphere heat treating units are designed with 100% forced convection heating to provide greater efficiency. Built for temperatures up to 1850° F., they can profitably handle a wide range of work, both in small lots and in production runs.

These are some of Ipsen's outstanding design features which will give you greater efficiency in processing:

1 **100% Forced Convection Heating**—powerful alloy fan forces atmosphere around radiant tubes, under floor, and *through* the work. Provides faster heat recovery and uniform circulation. Fan is removable through baffle opening in hearth.

2 **Long Life, Radiant Tubes** — withstand high temperatures, assure long, trouble-free service. Light in weight, are easier to remove, cost 50% less to replace.

3 **New Sealed-in Silent Burners**—provide accurate flame control, fast temperature buildup, *complete* combustion and uniform temperature.

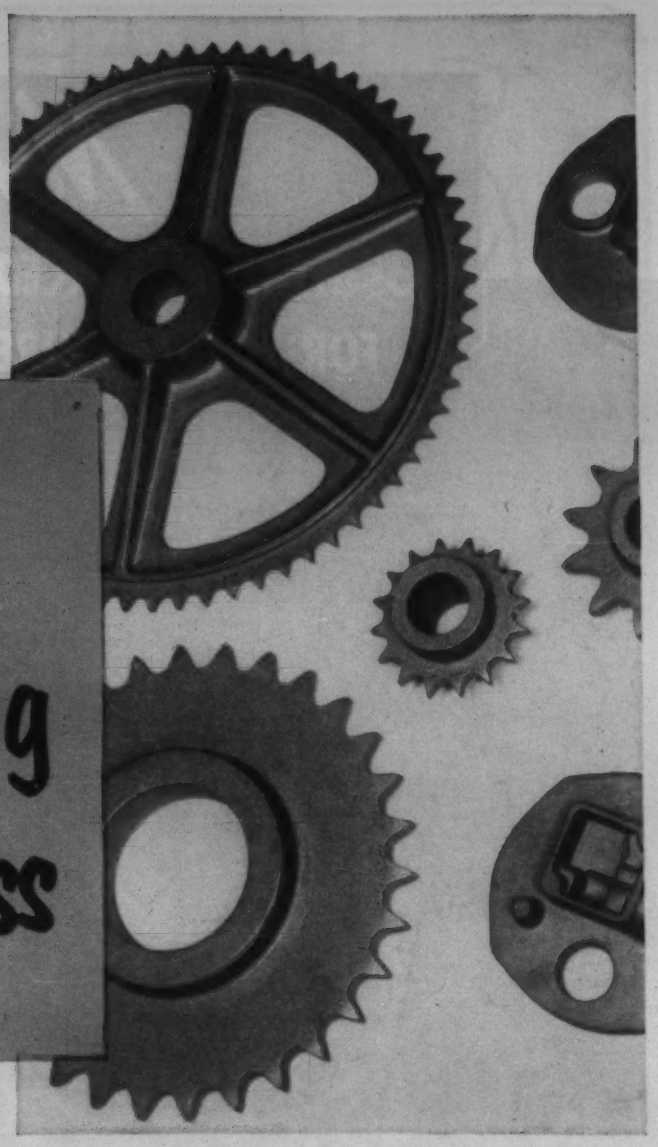
4 **Demountable Baffles** — assure complete circulation of atmospheres through the load and maintain uniform work temperature. Sectional-type construction permits easy replacement. Complete unit can be removed in ten minutes.

Send **Samples for Free Estimate** — find out how the new Ipsen Units can be applied to your job. Samples of your work will be run, procedures established in our new, modern lab, and cost estimates given without obligation.

Write **for New Literature** — illustrates new design features, gives complete specifications of various units.

IPSEN INDUSTRIES, INC. 720 South Main Street; Rockford, Illinois

Universal Units for CARBONITRIDING · CARBURIZING · HARDENING · BRAZING · MARTEMPERING



Foundries are proving that

A lot of machining is needless

...another case where Durez produced the right answer in RESINS

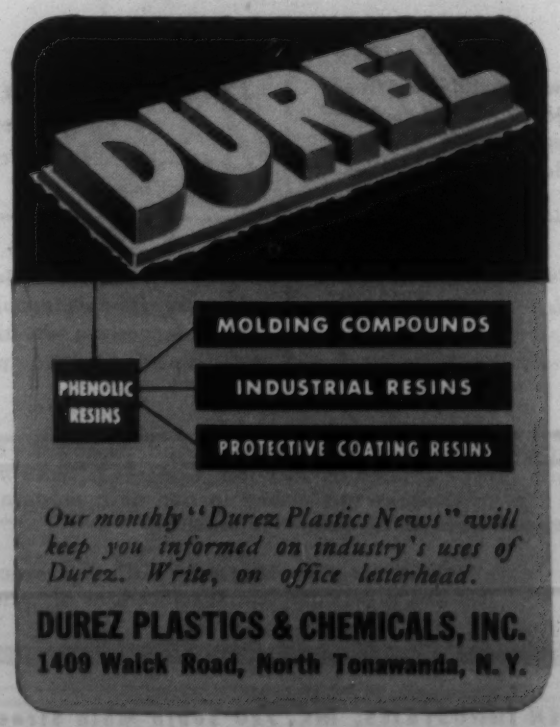
● A revolution in casting methods now under way in the nation's foundries is destined to save millions in manufacturing costs.

With the new method, metal castings produced in Durez resin bonded shell molds conform to required dimensions very closely, and have such smooth surfaces that in some cases machining is eliminated completely. One large casting that formerly required 27 pounds of metal removal per piece now needs less than three.

Success depends largely on the bonding resins. Working with leading foundries from the start, Durez has perfected a phenolic resin with exceptionally fast cure and rigid set. The resin facilitates mass production and makes it easier to obtain castings with desired qualities of structure, dimensional accuracy, and finish.

This is one way in which Durez — leading specialists in phenolics — has contributed through research to industrial advance. Others are in the fields of abrasives, rubber, wood waste utilization, paper products, printing inks, wax emulsions, and of course, plastic molding compounds.

If you have a product or process that may call for the mechanical, chemical, and electrical values inherent in phenolics, why not talk things over with men who specialize in them? Our experience is at your service.



PHENOLIC PLASTICS THAT FIT THE JOB

New Materials and Equipment

ments are essential. A magnetic or electronic contactor, as well as a Sequence-Weld timer, is necessary for the Type EB-3 Welder.

Kit Simplifies Identification of Metals

Chem Kit for Industry, Inc., 507 Fifth Ave., New York -17, has developed a chemical testing kit for the metal working industry which is said to permit simple, on-the-spot identification of around 40 types of metals and alloys.

The development of the Metal Chem Kit was based on the fact that certain chemicals react with certain types of metals and assume a distinctive color. By placing a chemical on the surface of the metal to be tested, and observing the resulting color, the constituents of the material can be determined. The manufacturer states that the accompanying instruction book is concise and detailed so that the layman can easily carry out the qualitative tests.

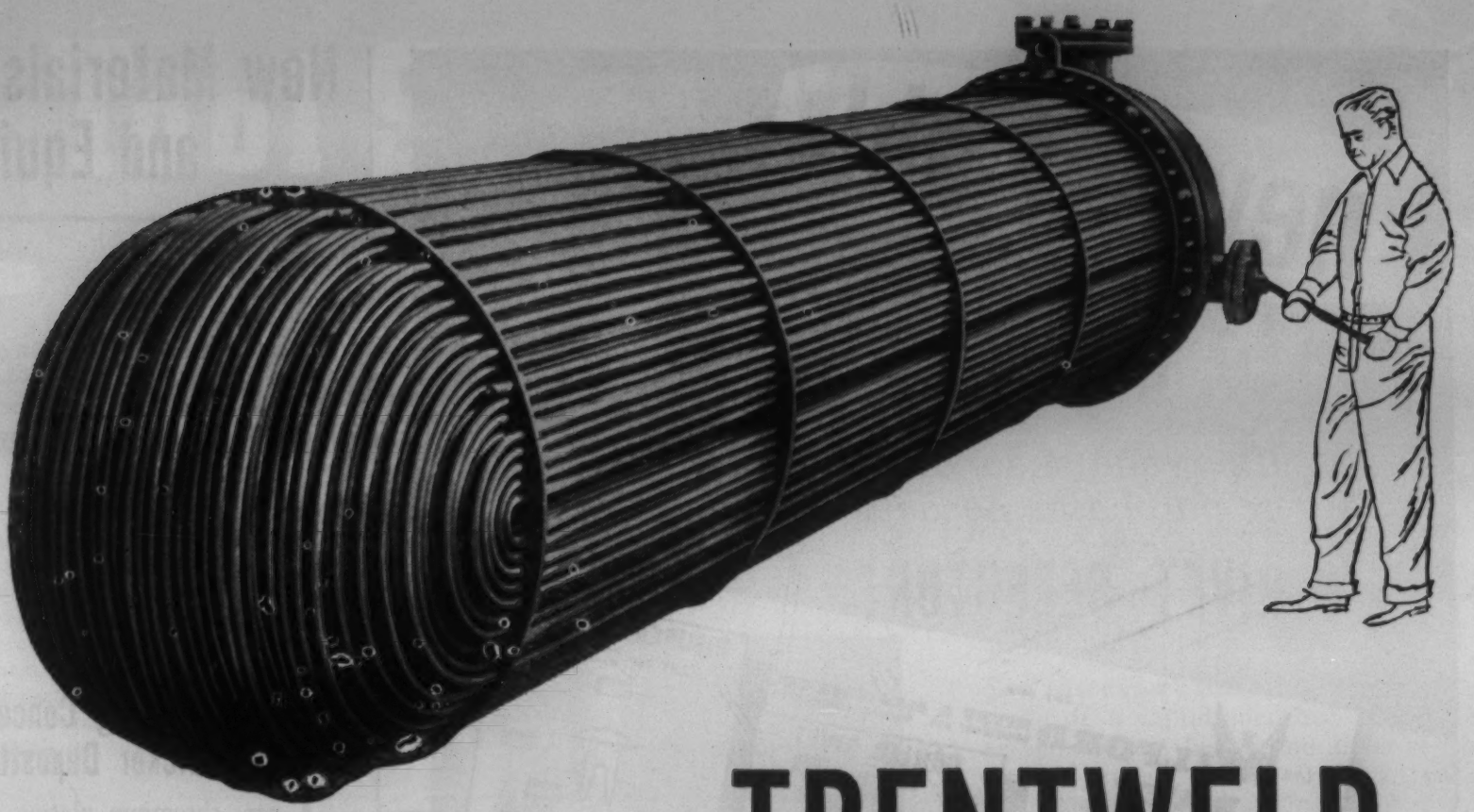
Positive results are said to be easily obtainable, for instance, in differentiating between nickel, Inconcel and monel; between chrome stainless steel and nickel chrome stainless steel; between antimony, zinc, cadmium, tin, lead 2S aluminum and molybdenum; and between admiralty metal and phosphorous bronze.

The kit weighs 8 lb in its mahogany carrying case, costs $50 and contains enough chemicals and utensils to conduct over five hundred tests.

Improved Vibration Fatigue Tester

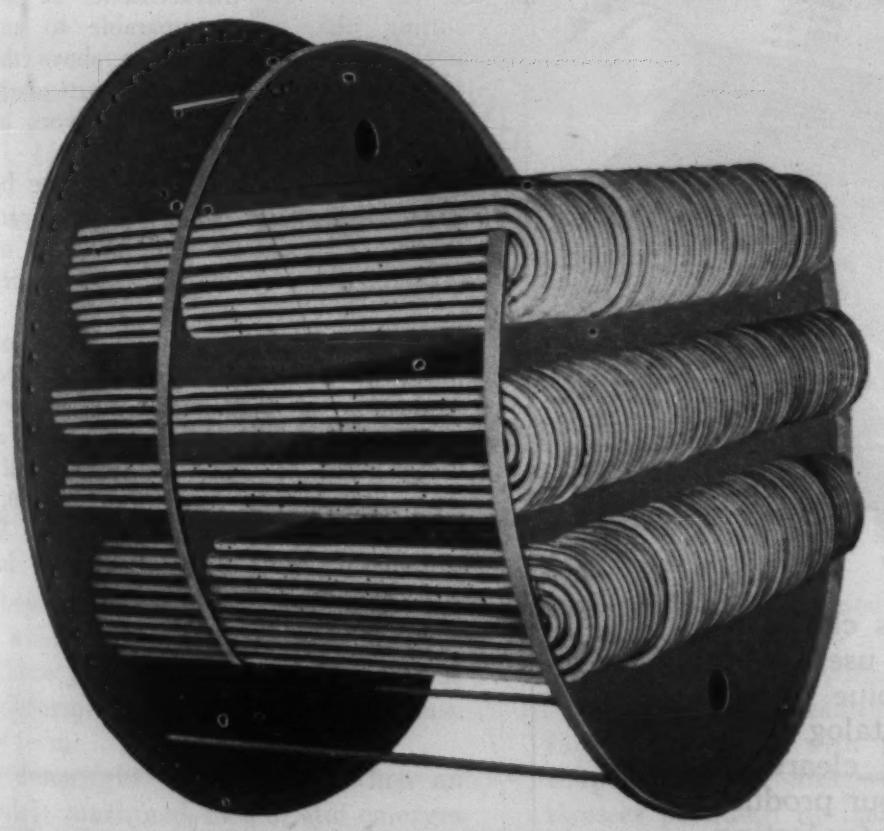
The Model 100-HL-A Vibration Fatigue Tester recently introduced by *All American Tool & Mfg. Co.*, 8027 Lawndale Ave., Skokie, Ill., incorporates improved table support and mounting hole arrangement with increased bearing contact to replace its predecessor, the Model 100 HA. The company says that with this machine, the type of horizontal vibrations to which a part or product will be subject when in use can be simulated, and its ability to withstand those vibrations readily determined. The machine may be set to produce vibrations of constant frequency or to repeat cycles of graduated frequency.

Four linkage arms, equipped with ground steel pins and Super Oilite bushings support the table, and the bearing contact is said to be increased fivefold. The mounting holes are jig-drilled in a



you can't beat TRENTWELD

for *your* tubing requirements



Heat Exchangers built by Vulcan Manufacturing Division, Vulcan Copper & Supply Co., Cincinnati, Ohio.

Whether it's heat exchangers or milking machines, chemical equipment or fountain pens, or any of a thousand other applications, you just can't buy better tubing than TRENTWELD stainless and high alloy tubing.

One reason is that TRENTWELD stainless *welded* tubing is a product of tube mill specialists . . . worlds apart from job shop fabrication. All of our facilities are devoted solely to the production of top quality tubing.

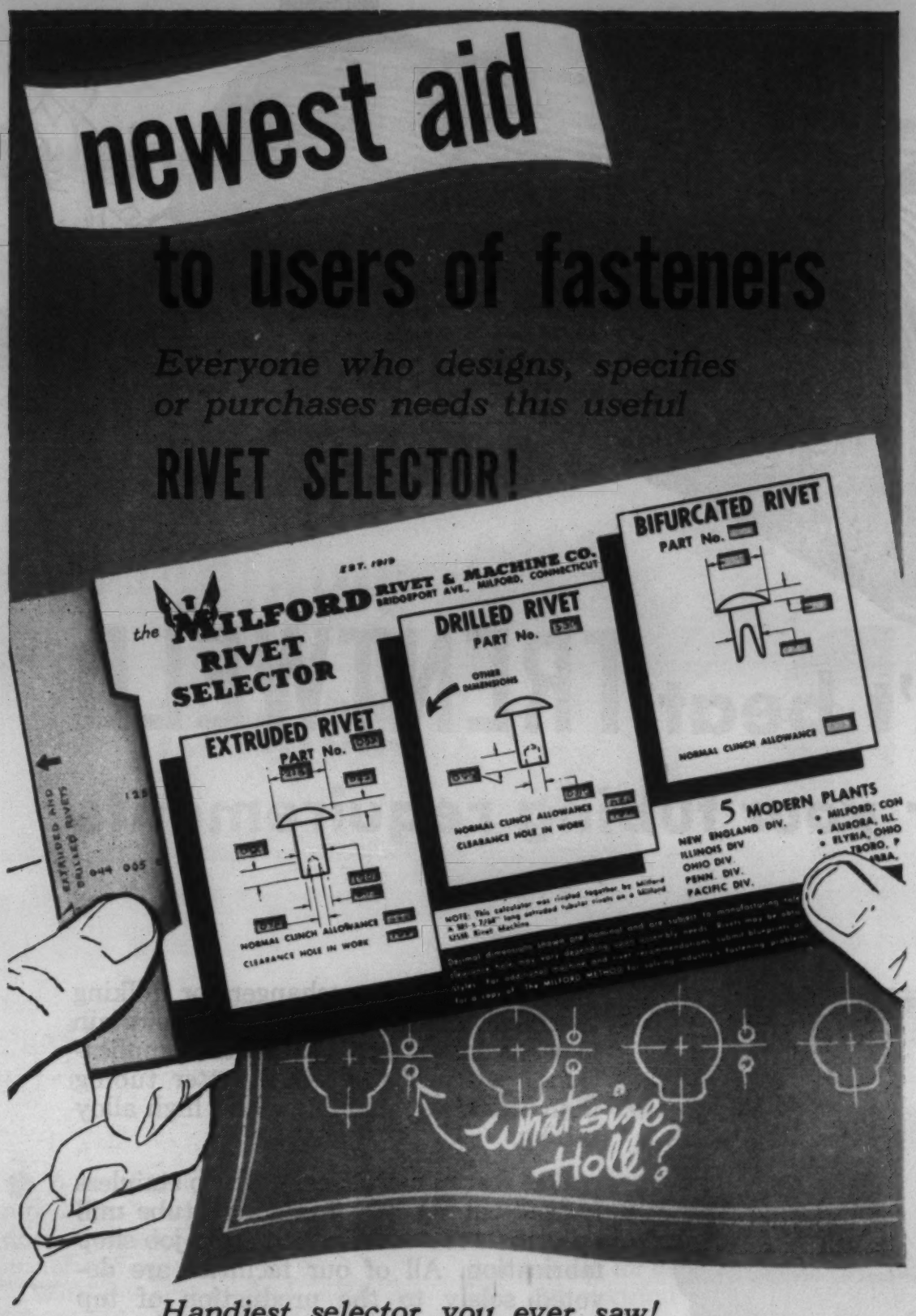
TRENTWELD is made by an exclusive fusion-welding process in which no filler rod is used. Each piece has an accurate uniformly sound weld that is indistinguishable from the parent metal and just as strong and corrosion-resistant.

TRENTWELD is available in an extremely wide range of sizes from ⅛" to 40" O.D. and up, in most grades, gauges and finishes. Trent engineers are experienced in solving tubing problems in many fields. Write now and let us help with *your* application problem.

TRENTWELD

STAINLESS STEEL TUBING

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of CRUCIBLE STEEL COMPANY OF AMERICA)



Handiest selector you ever saw!

Simplifies your job; saves time, speeds choice of right fastener. Easy to read, easy to use, handsomely lithographed in red, white and blue. Shows various tubular and split rivets, part catalog number, normal clinch allowance, size of clearance hole in work and other details to aid your product manufacturing. Sturdily riveted together for lasting use. Write for yours today!

EST. 1919
MILFORD

The name to *RIVET* in your memory for fasteners.

THE MILFORD RIVET & MACHINE COMPANY

859 BRIDGEPORT AVENUE, MILFORD, CONNECTICUT
834 ILLINOIS AVENUE, AURORA, ILLINOIS
1110 WEST RIVER STREET, ELYRIA, OHIO
30 PLATT STREET, HATBORO, PENNSYLVANIA
721 SO. PALM AVENUE, ALHAMBRA, CALIFORNIA

New Materials and Equipment

symmetrical pattern so the object being tested can be turned through 90 deg. This hole pattern also permits interchangeability of fixtures between models of same load rating.

Chromium Plating Concentrate for Thicker Deposits

A new chromium plating concentrated solution, Chromasol No. 2, has been developed by the *Industrial Chrome Div. of Ward Leonard Electric Co.*, Mount Vernon, N. Y., for use where desired deposit thicknesses range up to 0.015 in. or more. The manufacturer claims that the hardness characteristics of the resulting plate are comparable to any conventional chromium plate above the file hard range, and make it particularly adaptable for use in salvaging worn or undersize parts, gages and tools.

The solution is prepared for use by adding three parts water to one part Chromasol concentrate and the rate of deposition is approximately 0.002 in. per hr.

It is said to have a high density of deposit, good corrosion resistance, good reproduction of base metal finish, low coefficient of friction and heat, and a melting point of 3488 F. Its approximate yield per qt of concentrate is 1,000 sq in. at a thickness of 0.002 in.

Chromasol No. 2 is available in quarts, gallons and carboys.

Low Temperature Rod for Joining Tungsten Carbide

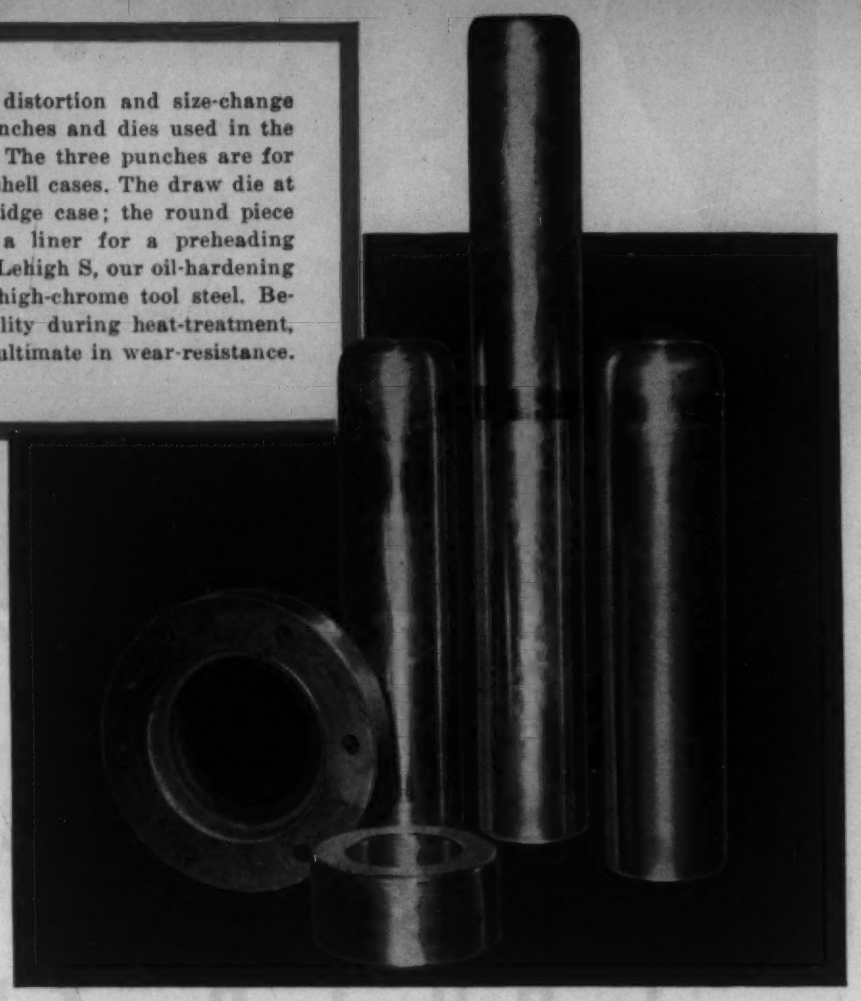
EutecRod 1602, developed by *Eutectic Welding Alloys Corp.*, 40-40 172nd St., Flushing, N. Y., is said to have unusual "flowing" characteristics on tungsten carbide, as well as other difficult-to-braze alloys and steels. It flows smoothly even at elevated temperatures, permitting the use of silver brazing-type joints on all alloys which have refractory oxides of chromium, vanadium, nickel and so forth.

The rod is said to have the lower heat input required for "L" and butt joints where a white solder-type alloy is desired on stainless steel. It is available in 3/64, 1/16, 3/32 and 1/8 in. dia.

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

In the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. Export Distributor: Bethlehem Steel Export Corporation



Only the minimum of distortion and size-change can be tolerated on punches and dies used in the cold-extruding of steel. The three punches are for cold-drawing 105 mm shell cases. The draw die at left is for a 5-in. cartridge case; the round piece in the foreground is a liner for a preheading die. All are made from Lehigh S, our oil-hardening grade of high-carbon, high-chrome tool steel. Besides its inherent stability during heat-treatment, Lehigh S provides the ultimate in wear-resistance.

There's no such thing as a non-deforming tool steel

Shrinkage, growth, and warpage—all occur when a tool is heated for hardening. There just isn't a tool steel which is "non-deforming" in the absolute sense of the term.

It's downright discouraging when an accurately machined tool or die emerges from the heat-treating furnace with its shape distorted or its dimensions way beyond the allowable tolerances. Yet, this experience is quite common.

In many instances the change in size caused by heat-treatment is not so great as to cause any trouble. Proper grinding, to remove scale and to obtain exact tool dimensions, is often all that is necessary. However, excessive warpage or size change can make it costly, even impossible, to restore a tool to the proper shape or correct dimensions, either by grinding or by corrective heat-treatment.

It's obviously important for both toolmakers and heat-treaters to understand the causes of distortion and how it can be controlled within reasonable limits. The design of tools, the grade of tool steel used, and heat-treatment procedures—all these factors have a bearing on the degree of distortion which will occur.

Warpage, for example, is usually a factor associated with the geometrical shape of a tool and with the thermal stresses produced by lack of uniformity in heating or cooling operations. The composition of a tool steel has very little to do with the occurrence of warpage.

On the other hand, the growth or shrinkage of tools is the result of volume changes caused by the hardening operation. Each grade of steel has certain characteristics of inherent distortion. And it varies considerably with the composition. Carbon tool steel, for example, has a distortion "factor" of approximately .002 to .004 in. on the plus side. A high-carbon, high-chromium grade, such as our Lehigh H, has a factor of only .0005 in., plus or minus.

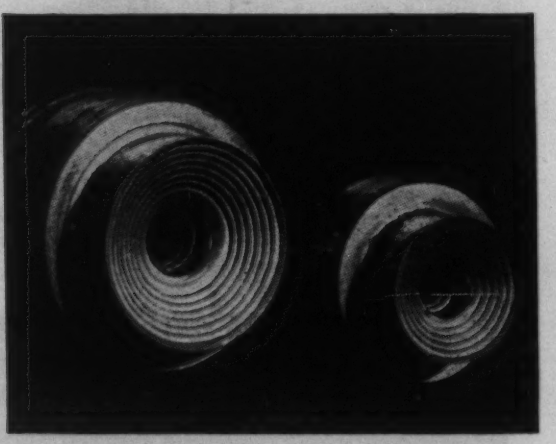
If you'd like a printed discussion of this subject write to our Publications Dept. at Bethlehem, Pa., for the booklet "Distortion of Tool Steels in Heat Treatment."

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Avoid drastic changes of section in tool design

You can expect trouble whenever a tool made of a liquid-quenched steel is designed so that heavy and light sections are adjacent. When such a tool is quenched, the light sections cool rapidly and harden before the adjacent heavy sections. Quenching stresses are set up which often exceed the strength of the steel. Cracking is the result.

Although such tools fail during heat-treatment, poor tool design must take the blame. Troubles of this sort are sometimes avoided by differential hardening or making this type of tool as a two-piece assembly. But if a one-piece construction is necessary, then it's best to use an air-hardening steel.



FOR TOOTHPASTE TUBES

These intricately machined dies are used in shaping the tapered neck and tip of toothpaste tubes which are extruded from round slugs of aluminum. When a punch is driven downward towards the die, the aluminum "biscuit" is trapped between the punch tip and the die and is extruded by the heavy pressure, flowing upwards along the cylindrical punch to form the tube body.

The dies pictured are made from our 67 Chisel tool steel, a chrome-tungsten grade of shock-resisting steel that's ideal for tools and dies requiring plenty of impact strength. Although it is principally a shock type of steel, 67 Chisel is readily carburized whenever extra wear-resistance is needed . . . without sacrificing the advantages of its tough core.

Easy to machine and heat-treat, 67 Chisel is stocked by distributors of Bethlehem tool steel in principal cities.

For Your Ferrous Casting Needs Get These...

Freedom from . . .

1 Porosity
2 High Cost Material
3 Expensive Machining
4 Metallurgical Variation

with

PERMANENT MOLD Gray Iron Castings

Permanent Mold Gray Iron Castings by DOSTAL offer many advantages. Their structure is uniform and surface scale is eliminated. These 2 factors permit higher speed machining with faster feeds. The dimensional accuracy and uniformity of DOSTAL Permanent Mold Castings reduces machining operations to a minimum. Permanent molded castings are uniform in hardness and their structure is dense and porous-free.

Write Us Now — Find out how you can cut the costs of your products through the use of Permanent Mold Gray Iron Castings

DOSTAL

FOUNDRY and MACHINE COMPANY
2510 Williams Drive
Box 180 Pontiac, Mich.

The screen on the cathode tubes used in the memory frame of digital computors must be in even contact with entire tube face.

Cementing Metal Screens to Cathode Ray Tubes

by R. W. HOLMES,

Mechanical Engineer, Argonne National Laboratory

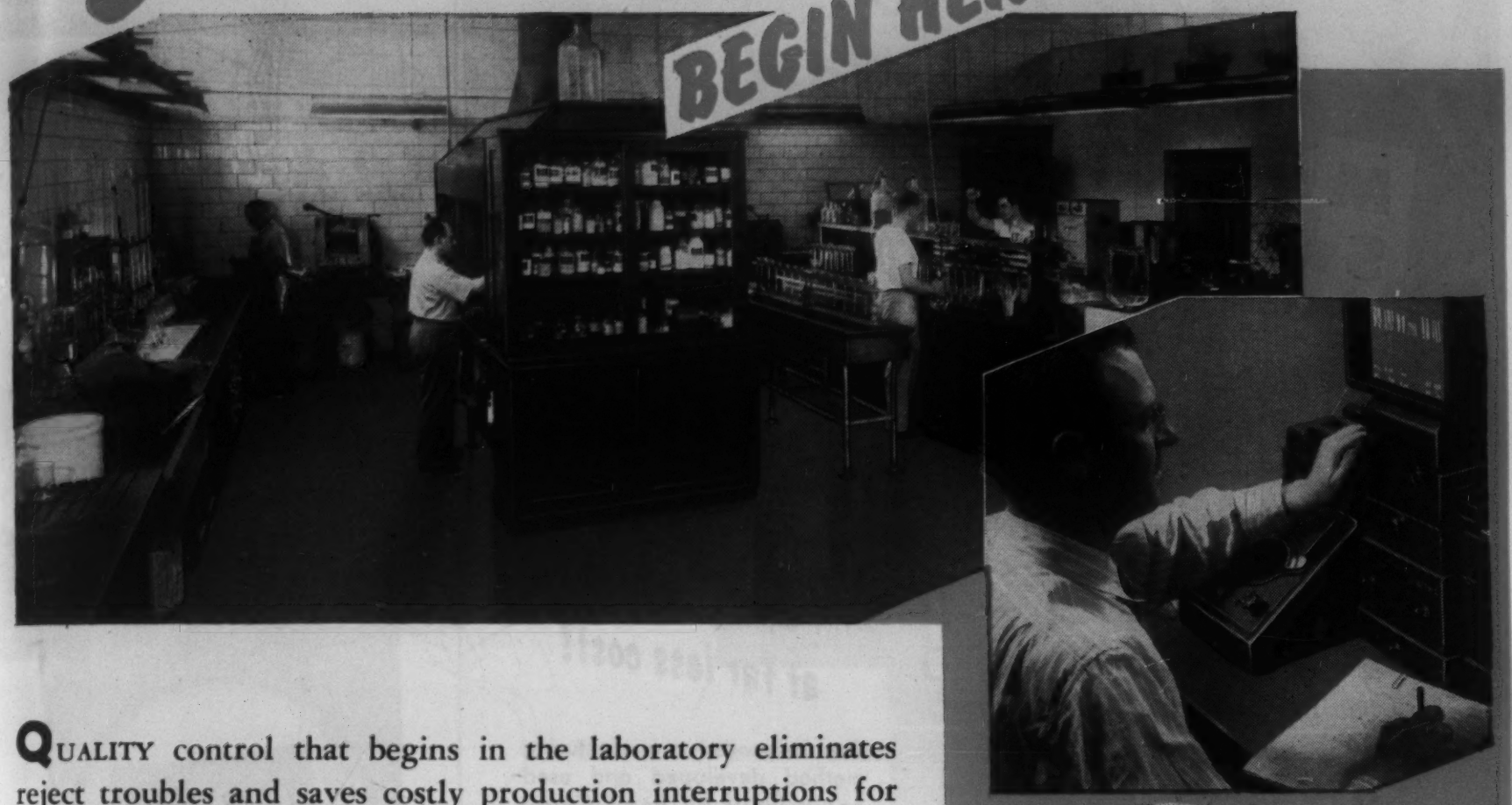
New Method 1) accomplishes job at lower cost, 2) reduces breakage, and 3) provides even contact of screen over entire tube face.

● THE CEMENTING OF FINE mesh screens to the faces of cathode ray tubes was an important operation in the construction of the memory unit of Argonne National Laboratory's new electronic digital computer (AVIDAC). This was accomplished efficiently and at low cost by use of a variation of the vacuum bag molding technique, developed in the Laboratory's Central Shops.

A basic requirement was that the screens be in even contact with the entire face surfaces. Conventional approaches to the problem, e.g., use of rubber pressure pads backed-up with formed blocks, and use of inflated bags held in close contact with the face proved to be impractical due to non-uniformity of the tube faces and because of the excessive

(Continued on page 186)

SAVINGS for Users of PERMITE ALUMINUM CASTINGS

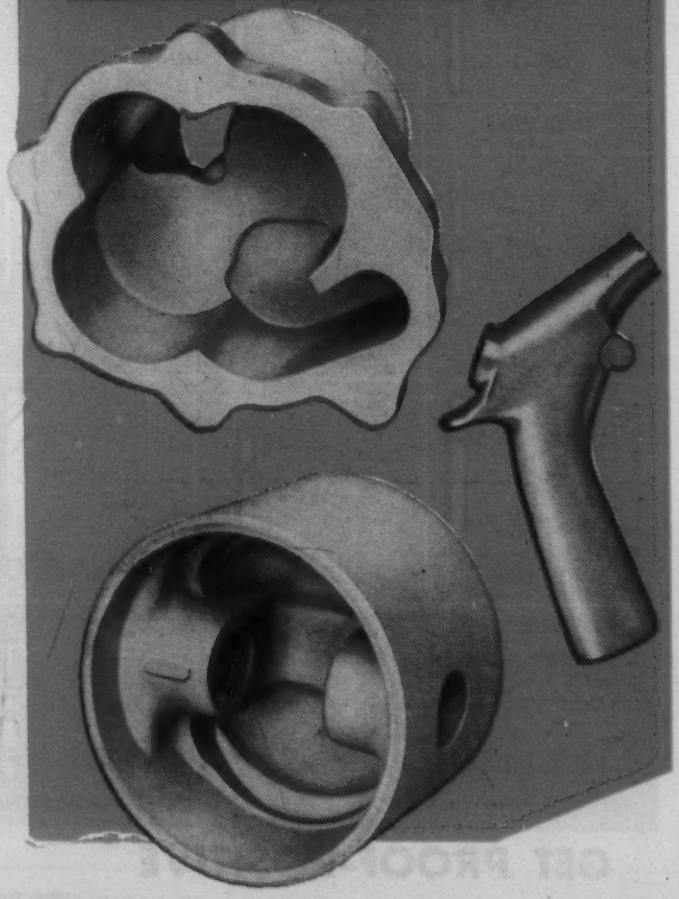


QUALITY control that begins in the laboratory eliminates reject troubles and saves costly production interruptions for users of Permite Aluminum Castings.

A first step in Permite quality control is spectrographic analysis to determine that the metal fully meets alloying specifications. X-ray examination of castings on a mass production basis assures castings free of hidden flaws.

Surface imperfections, invisible to the naked eye, are detected by the use of modern Zyglo black-light inspection. Checks made on the Optical Comparator, Angle Computer, and other advanced instruments at different stages of production insure dimensional accuracy.

Yes, Permite Castings, with quality proven before shipment, will save costly slow-downs, keep your production lines humming. Send blueprints or specifications on your castings requirements for recommendations and estimate.



ALUMINUM INDUSTRIES, Inc. - Cincinnati 25, Ohio

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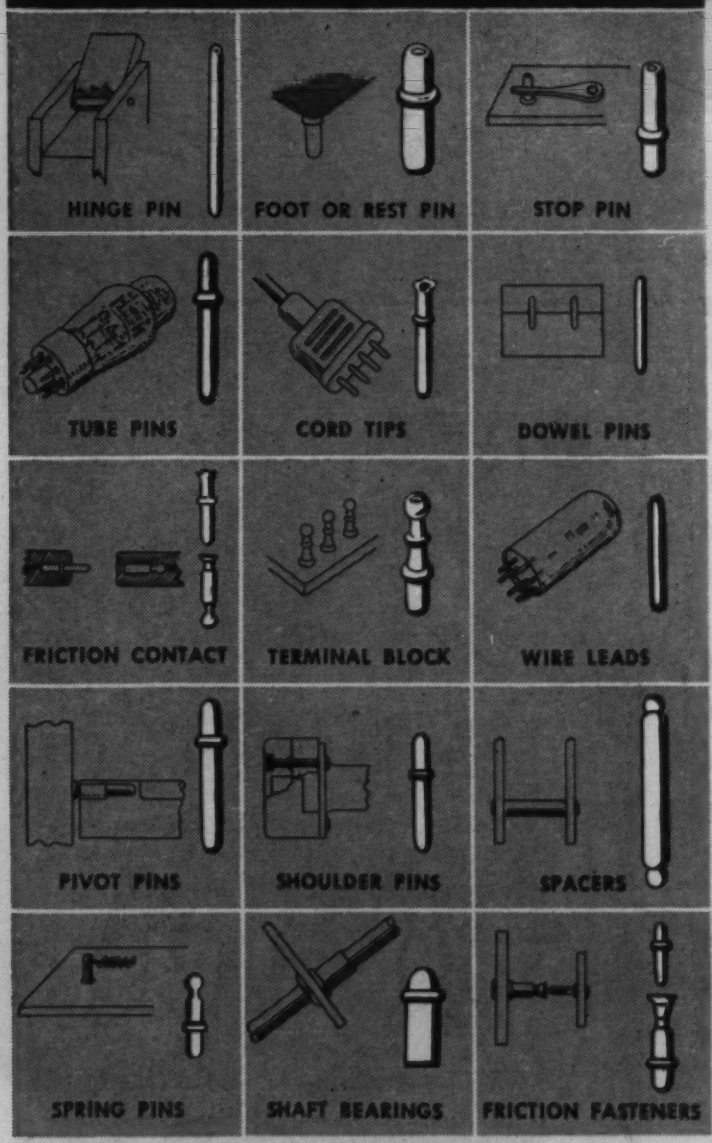

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Tiny Parts to your Specifications at far less cost!

The advanced manufacturing method developed and used exclusively by Bead Chain swages practically any type of small tubular part from flat stock into precision forms with positive, tight seams . . . and does it *Automatically*. If you can use high-volume production . . . we can deliver it at a much faster rate . . . and at far less cost! Scrap is eliminated! Deliveries to you are dependably prompt!

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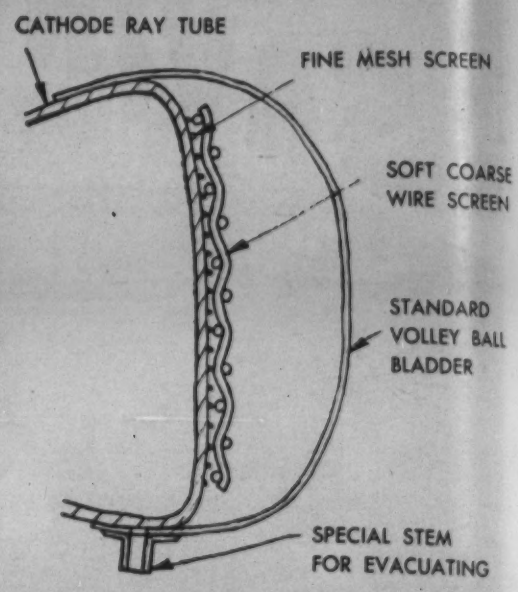
THE BEAD CHAIN MANUFACTURING CO., BRIDGEPORT 5, CONN.

Cementing Metal Screens

continued from page 184



Sketch shows elements of set-up used in the cementing operation.

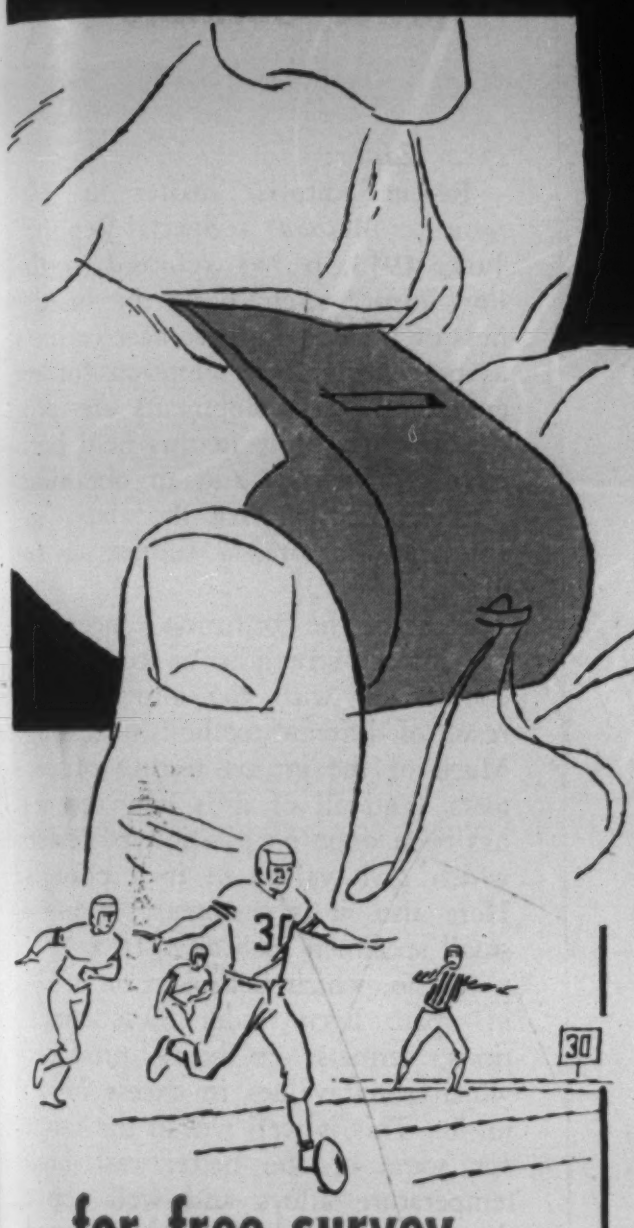
Photo above shows position of fine mesh screen on face of cathode ray tube.

drying time resulting from the prevention of normal air circulation. Inasmuch as there was no increase in pressure, the possibility of tube breakage was reduced to a minimum.

A round hole, slightly smaller than the maximum diameter of the tube, was cut into a standard volleyball bladder. The tube face was coated with a solvent type cement, and the fine mesh screen was attached. A soft coarse wire screen was then placed on top of the mesh screen and the entire face assembly was then inserted into the bladder opening. An evacuating stem was connected to a vacuum pump and all air in the bladder was exhausted.

By the use of this method, very close contact over the entire face of the tube was achieved. The coarse wire screen, which was removed from the completed unit, prevented air entrapment and the evacuated space effectively accelerated the rate of solvent evaporation.

give the GO -signal to DETREX for guaranteed phosphate coating



Detrex has been working with phosphate coatings for rust prevention and better paint adhesion for over twenty years.

Today, Detrex phosphate coatings have gained rapid acceptance by manufacturers of painted products from coast to coast. This acceptance is based on proven advantages . . . exceptional rust protection for metal surfaces, excellent fine-grained crystalline structure that literally locks paint to the metal, and economy and ease of application.

There is another important reason for the growing popularity of Detrex phosphate coatings . . . Detrex One-Stop Service. This exclusive Detrex service places the responsibility for the *complete* process in the hands of one competent company. On present operations, both cleaning and phosphating chemicals are produced by Detrex—on your new applications, Detrex produces the equipment, too. In either case, *the results are guaranteed!*

For a more durable paint finish, for economical, easy-to-control processing, for *guaranteed* performance—give the GO-signal to Detrex.

for free survey

At no obligation to you, the Detrex field man in your area will come in and survey your present or proposed operations. There is no cost for the service. The result will prove to you the money-saving advantages of Detrex service. Just fill out and mail the coupon below . . . our field man will call you for the most convenient time to come in.

DETREX CORPORATION,
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DETROIT 32, MICHIGAN

Please have the Detrex man in our area make an appointment to survey our operations to point up ways of cutting cleaning costs.

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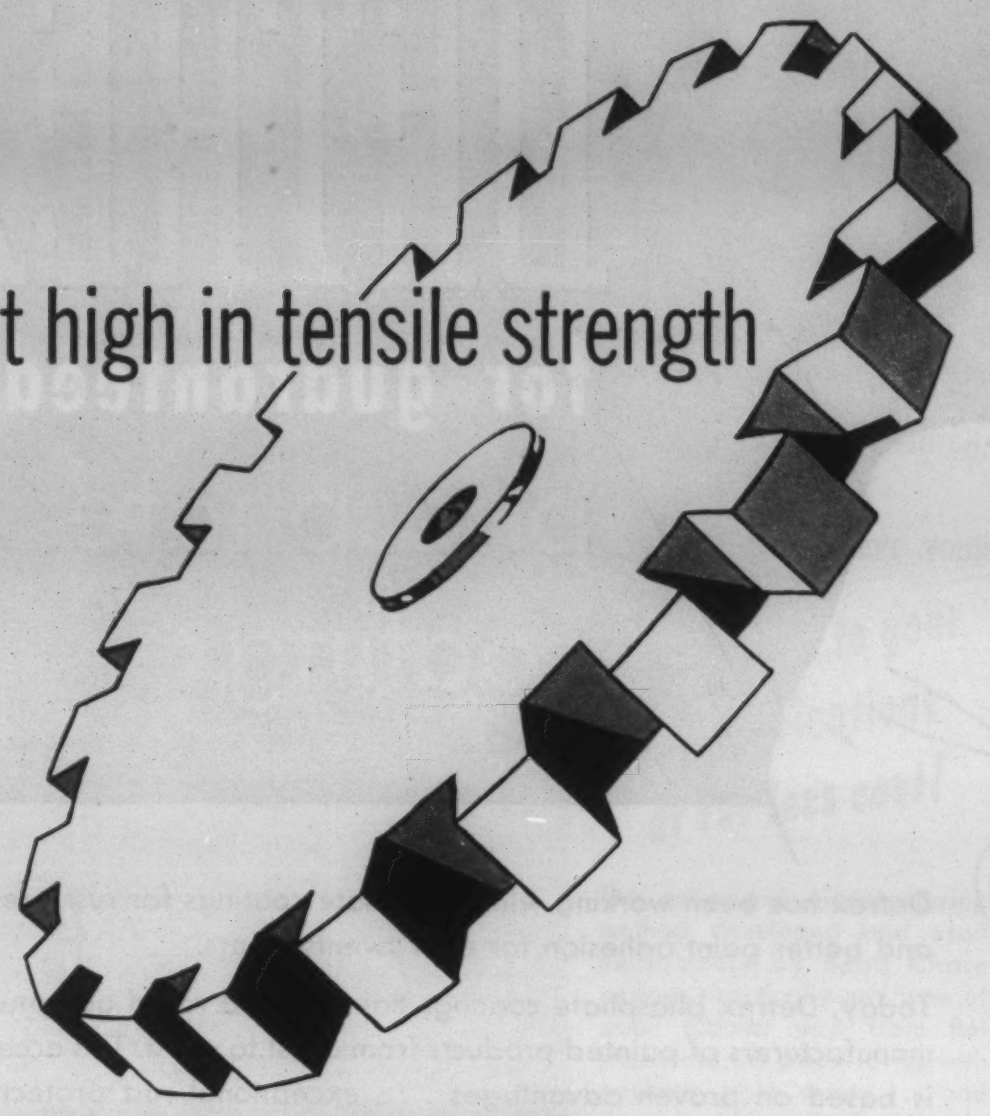

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Write now for complete information of iron powders with alloys of varied chromium-nickel contents. Your inquiries will receive prompt, interested attention. Specify Bulletin 800-A.

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A Letter to the Editor—

Impact Strength of Newer Cermets

Dear Editor:

Recent editorial matter in *Materials & Methods* ("Special Report," June, 1953, p 71) referred to the low impact strength or the brittleness of titanium carbide base cermets as preventing their adoption for jet engine use. Developments are proceeding so rapidly in this field both in new materials and in obtaining test information, that the above information is already subject to revision.

Some of the confusion concerning the impact strengths of cermets in comparison with the alloys is the result of different methods of testing. Much of the impact testing of cermets (and all of it is very recent) has been done on plastic type testers which give values in inch pounds. Here also, it is customary to use a small specimen such as 3/16 x 3/16 x 1½ in. which is broken on a 1¼ in. span. Even under these conditions, cermets are being produced which show values in excess of 20 in.-lb. This is well within the range for some of the better cast high temperature alloys and well above those of some which are being used in engines.

Alloys have generally been tested on impact machines of higher capacity giving values in inch pounds and using a specimen 0.394 x 0.394 x 2.165 in. in size. On this basis also, the cermets show themselves to have good impact resistance as measured by the Charpy method. Some typical values for titanium carbide base cermets (Kentanium) are as follows:

Material	*Binder*	*%*	*Impact Resistance, ft/lb*
Kl51A	Nickel	20	4.0
Kl52B	Nickel	30	4.8
Kl53B	Nickel	40	5.4
Kl62B	Alloy	30	3.8
2587	Alloy	50	6.7
2560	Alloy	50	8.3
SC 131	Alloy	40	5.2

It should be noted that some of the above compositions having the highest impact strengths also have high

(Continued on page 190)

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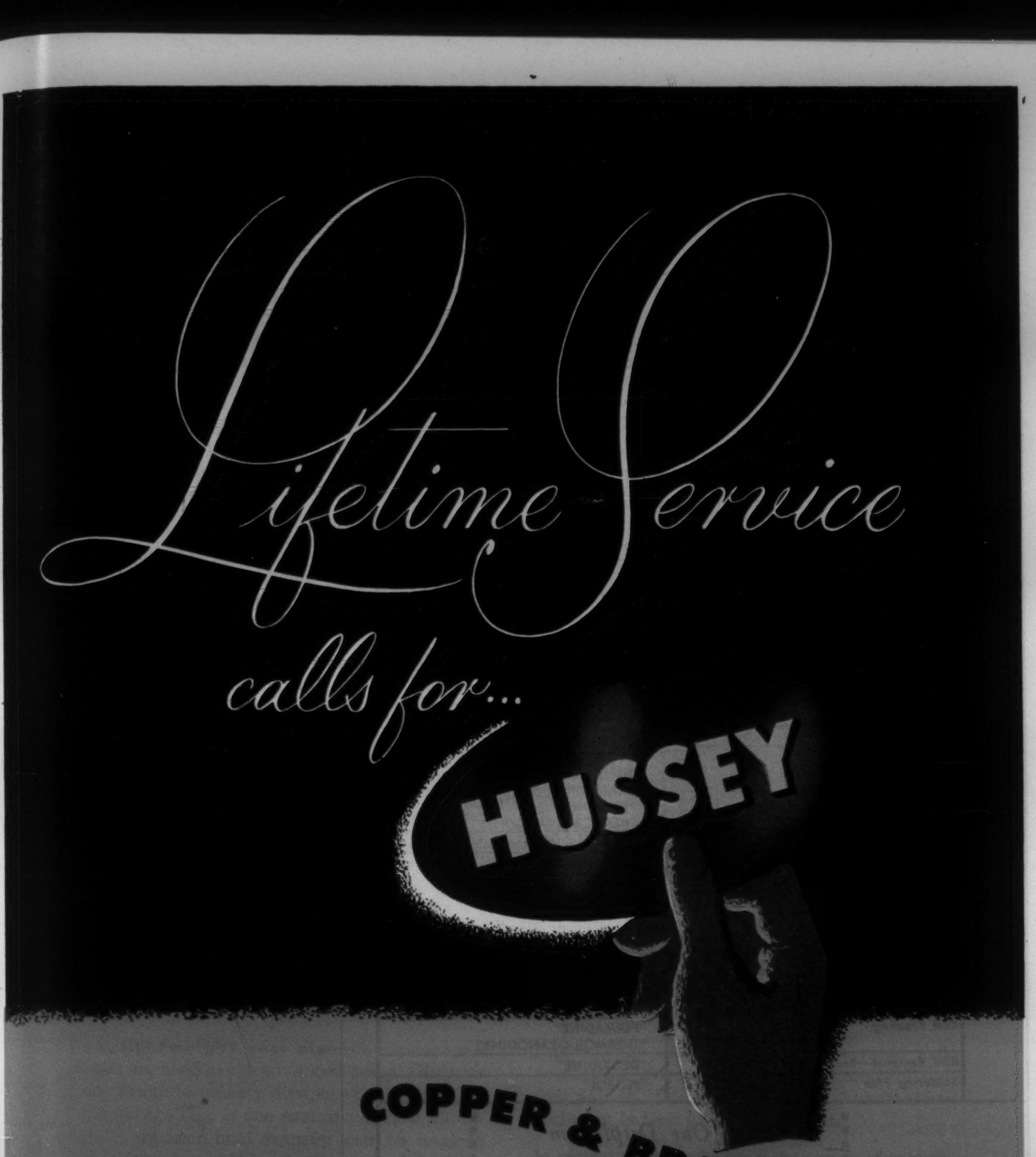

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METAL	OPERATION	ACP CHEMICAL
ALUMINUM	Cleaning	"DEOXIDINE" "DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Preparation for Painting	"ALODINE" "DURIDINE" "DEOXIDINE"
	Protection from Corrosion	"ALODINE"
GALVANIZED IRON, ZINC, AND CADMIUM	Cleaning	"DURIDINE" "ACP RIDOLINES AND RIDOSOLS"
	Corrosion Proofing	"ZINODINE"
	Paint Bonding	"ZINODINE"
	Phosphate Coating, in Preparation for Painting	"LITHOFORM"
	Soldering Flux	"FLOSOL"
STEEL	Chromate Coating, in Preparation for Painting	"CROMODINE"
	Cleaning	"ACP RIDOLINES AND RIDOSOLS"
	Cleaning for Painting	"DEOXIDINE" "DURIDINE"
	Coating with Copper	"CUPRODINE"
	Drawing and Extrusion	"GRANODRAW"
	Paint Bonding	"CROMODINE" "DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Paint Stripping	"CAUSTIC SODA AND SOLVENT NO. 3"
	Phosphate Coating, in Preparation for Painting	"DURIDINE" "GRANODINE" "PERMADINE" "THERMOIL-GRANODINE"
	Phosphate Coating, to Protect Friction Surfaces	"THERMOIL-GRANODINE"
	Pickling with Inhibited Acids	"RODINE"
	Rust Prevention for Unpainted Iron	"PEROLINE"
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GENERAL OFFICES: AMBLER, PENNSYLVANIA

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A Letter to the Editor —

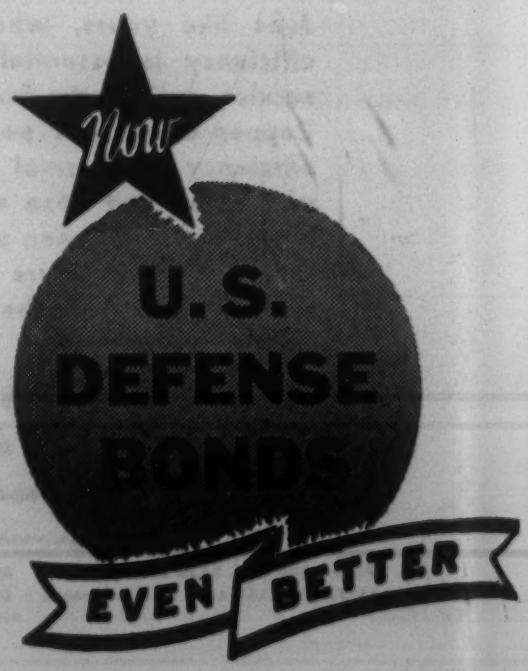
continued from page 188

temperature strengths up to 45,000 psi for 100 hr at 1800 F.

The ability of a part to withstand bouncing on the floor is a poor criterion for choice of an engine material. Nozzle vanes of one of the best cast alloys in use today have been known to break when accidentally knocked from a desk.

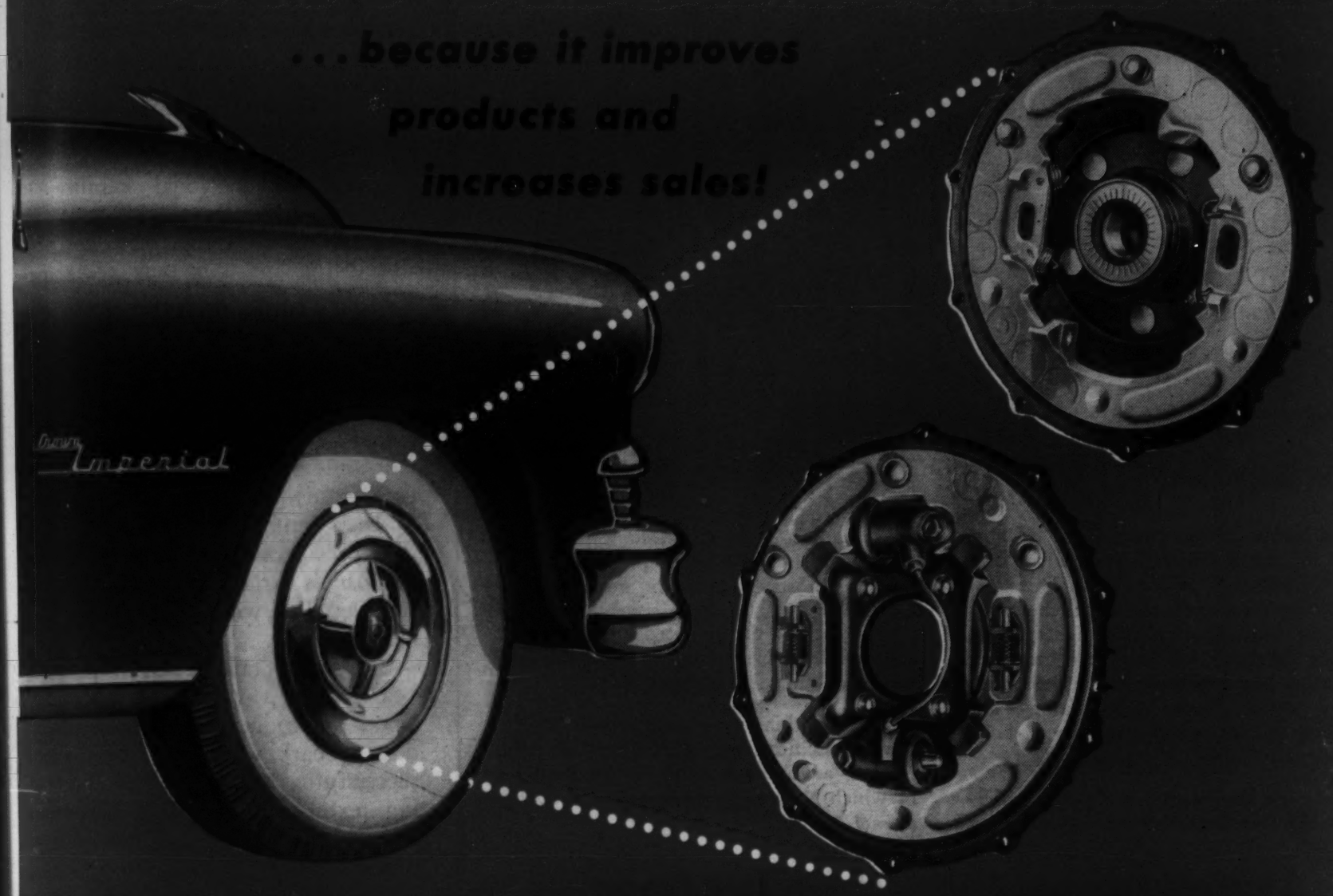
It is true that there are many problems connected with the use of cermets in jet engines. However, the problems can only be solved by accurate measurement and expression of their various characteristics since the combination of properties must be carefully tailored to the conditions to be met. Design also plays an important role.

Some of the more recently developed compositions have shown by service testing that they have adequate impact resistance for severe conditions. These include certain types of rolling mill guides which are subjected to severe thermal shock and wear as well as impact, scarfing torch protective rings and numerous other applications. The superior wear and oxidation resistance enable the titanium carbide compositions to outlast other materials from ten to a hundred times.



WHY ALUMINUM?

. . . because it improves products and increases sales!



CASE HISTORY: Chrysler Self-Energizing Disc Brake*

**Standard Equipment on Crown Imperial Models*

Two, lightweight, cast aluminum pressure plates are used in the advanced design Chrysler Disc Brake to quickly dissipate heat generated in braking. This is one example of how aluminum's superior heat transfer can be used to advantage . . . in this case to improve braking efficiency and to prolong brake life.

Other advantages that are proving equally beneficial to manufacturers and operators of cars and trucks include aluminum's low cost, light weight with strength, ease of fabrication, electrical conductivity and corrosion resistance. These factors have influenced the widespread use of aluminum for pistons, transmission and torque converter parts, carburetor bodies, generator and starter parts, battery trays, window frames, trim and a host of other parts and accessories. For more information send for the free folder, "Here's What The Automotive Industry Is Doing With Aluminum."

In almost every industry a change to aluminum has provided manufacturing economies, improved designs and, at the same time, increased sales appeal. Ask Reynolds Aluminum Specialists to help you apply aluminum's advantages to your products and production.

Call the nearby Reynolds office listed under "Aluminum" in your classified telephone directory. Also write for complete index of design and fabrication literature. Reynolds Metals Co., 2560 S. Third Street, Louisville 1, Kentucky.

"Mister Peepers" returns September 13th on NBC-TV. Consult local listing for time and station.

REYNOLDS ALUMINUM

MODERN DESIGN HAS ALUMINUM IN MIND

How Beryllium Copper Springs keep foods fresher...longer

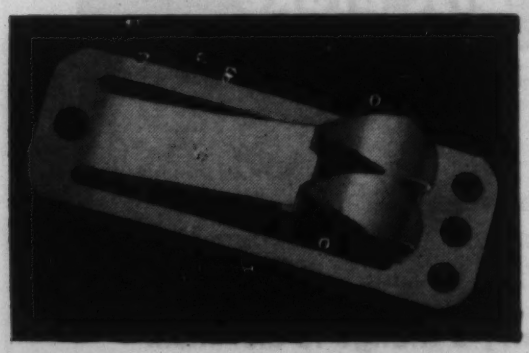
A BERYLLIUM COPPER SPRING is the "memory cell" of the defrosting mechanism of a leading household refrigerator. This small flat spring completely eliminates the necessity for remembering to defrost at the proper intervals. Thus, this beryllium copper spring functions in the defrosting timing cycle of the refrigerator — and through this increased efficiency, it helps keep foods fresher . . . longer.

The design engineers set rigid specifications for this defroster-actuating spring. They wanted, above all, maximum dependability and long life. The production department insisted on early and frequent deliveries after design details had been settled . . . and they wanted them in large quantities. And, naturally, the purchasing office demanded lower unit costs!

There's nothing too exceptional about these specifications. But there *is*, we believe, an unusual story in the manner in which they were exceeded—*on every count!*

I-S Micro-Processed Springs of Beryllium Copper

were chosen and are still being used for this installation because of their 4-way superiority:



(*1*) HIGHER DEGREE OF UNIFORMITY AND dependability than conventionally-made springs.

(*2*) I-S DESIGN ENGINEERS' SPECIALIZED experience in spring-making, aided in redesigning for our exclusive "strip spring" technique which permits hardening in multiple fixtures to assure the uniform dimensional and elastic performance. This also resulted in substantial unit-cost reduction.

(*3*) THIS SAME I-S EXCLUSIVE STRIP DESIGN showed further savings in subsequent assembly-line operations—such as cleaning, inspection and attaching of the silver contacts and elimination of costly hand adjustments.

(*4*) ONLY I-S EXCLUSIVE TECHNIQUES, methods and patented equipment could have produced these far superior springs within the time limits set by the production department.

You have the identical basic problems—time and unit costs, plus product performance. We feel that this particular spring application, clearly demonstrates two important Instrument Specialty features: *(1) our ability to produce a better spring, faster and usually at lower cost to you. (2) the specialized ability of our engineers to cooperate with your designers in meeting practically any exceptional problem that involves spring-making.*

It cost you nothing to compare methods and costs.

Instrument Specialties Co. Inc.
224-D BERGEN BOULEVARD, LITTLE FALLS, NEW JERSEY
Telephone Little Falls 4-0280

For full information on I-S Micro-processed Springs, write today for your free copy of Catalog 7; for Electronic Components, ask for Catalog No. 7-A.

News Digest

Wood Extrusion . . .

continued from page 8

takes coatings of paper, metal, or wood veneers. Veneered, it is stronger than most solid woods and has better dimensional stability. It will not warp. Panels ½ in. thick suitable for corestock can be produced for approximately 6½¢ per sq ft including material, labor and amortization costs.

Of particular significance to the building trades is a press now undergoing final development that extrudes 4 in. by 4 ft panels around elliptical dies. The panels can be used as double faced bearing walls as they come from the press. The die cores form vertical channels in the panels large enough to be used for electrical wiring, plumbing and heating ducts.

The Chipcraft presses produce board from a variety of materials; wood by-products from coarse sawdust to bark waste have been used successfully, and panels of interesting texture and physical properties have been made from flax shives, bagasse, peanut shells, and straw.

Beryllium Copper for Marine Use

Beryllium copper compares favorably with copper in corrosion resistance under many conditions of exposure to sea water and marine atmospheres, according to results of a two year series of exposure tests reported at the annual meeting of the ASTM.

In quiet sea water, the corrosion resistance of beryllium copper was less than 70-30 cupro-nickel and equal to phosphorous-deoxidized copper and arsenical admiralty. With increasing water velocity cupro-nickel maintained its corrosion resistance superiority but beryllium-copper offered better resistance than either copper or admiralty.

In atmospheric corrosion tests, beryllium-copper showed resistance superior to copper, phosphor bronze, and beryllium-cobalt-copper.

The results indicate that beryllium

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● The sleeve bearing is much lower in original cost than any other type from which you may choose. In over 90% of your applications a Johnson Sleeve Bearing will give long, trouble-free service . . . in many instances, for the life of the product in which it is installed. It is quiet, corrosion resistant, conformable, and simple in construction. Possibly you are buying more bearing than you need. You can simplify and save with Johnson Sleeve Bearings. They are available in cast bronze, cast aluminum alloy, bronze-on-steel, aluminum-on-steel, babbitt on steel or bronze, molded powder metal (pre-cast bronze powder), and graphited types. Johnson engineers will gladly consult with you on changing your designs to use economical Johnson Sleeve Bearings. Write for an appointment.

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INCH THICK

cut with the

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which uses

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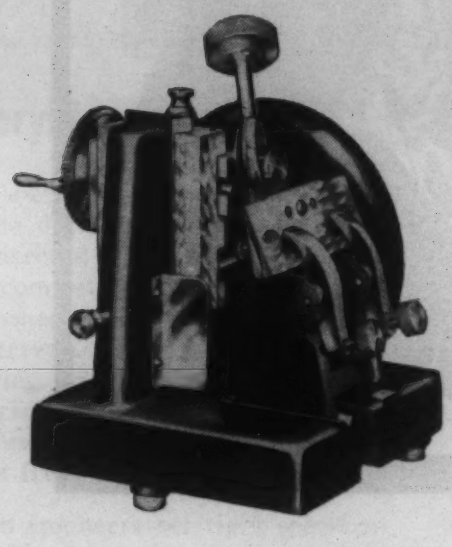
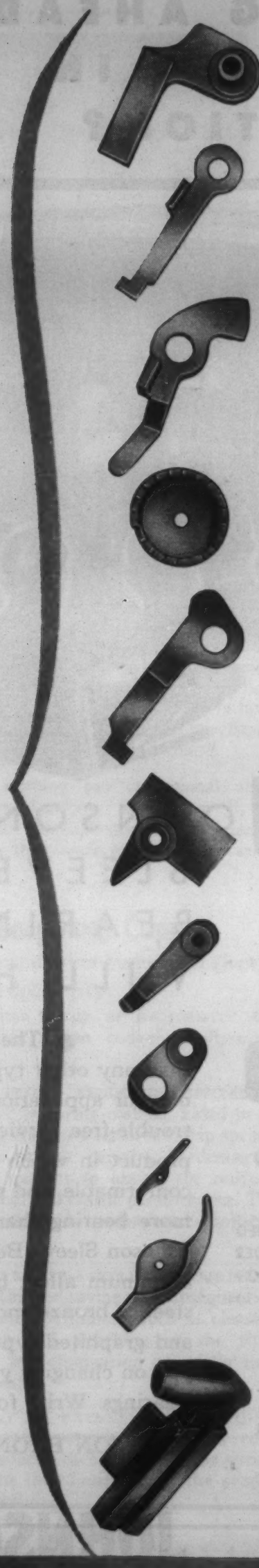
precision investment CASTINGS



International Equipment Co., Boston, Mass., manufactures the Microtome shown and other precision instruments. For the Microtome, they chose Hitchiner precision investment stainless steel castings because they could get extremely accurate parts with a minimum of machining. These castings also lend themselves to the very high, bright, smooth finish necessary on instruments of this quality.

Whatever your requirements may be in small castings, we will be happy to have you utilize our facilities and experience in solving your parts problems. Quotations furnished promptly on receipt of your prints.

BE SURE TO SEE US AT SPACE 2422, THE NATIONAL METAL SHOW



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News Digest

copper is a material to be considered in marine applications requiring both high strength and the corrosion resistance of copper.

Rare Earths For Ductile Stainless

Inherently hot-short, high-alloyed, austenitic stainless steels are transformed into ductile alloys by addition of small amounts of cerium and lanthanum in the form of mischmetal.

Carpenter Steel metallurgists Post and Beaver reported to the American Iron and Steel Institute that the transformation of working properties of hot-short stainless is the result of traces of the rare earth metals left in the steel. Addition of the rare earth metals in the form of oxides improves the workability and surface characteristics of inherently ductile austenitic stainless, but since the oxides do not leave traces of the metals in the steel they do not effect the hot-short grades.

The metallurgists reported that cerium fluoride additions to austenitic stainless steels containing titanium improved both the hot workability and surface characteristics of the material.

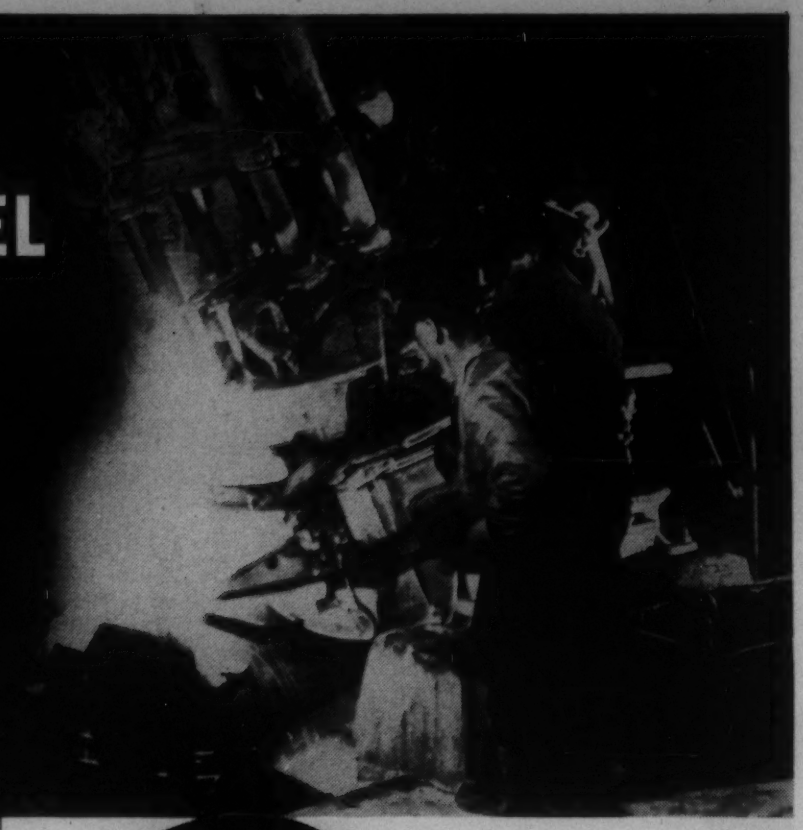
New Transistors To Extend Use

The first commercially available tetrode transistor was recently placed on the market by Sylvania Electric Products, Inc. and pentode types are expected to be available by the end of the year.

The development of transistors of a higher order of complexity will make possible even more efficient transistorized electronic equipment, particularly in the radio and TV field. While commercially acceptable

"WAUKESHA METAL" and WAUKESHA STAINLESS STEEL Castings . . . CORROSION TESTED

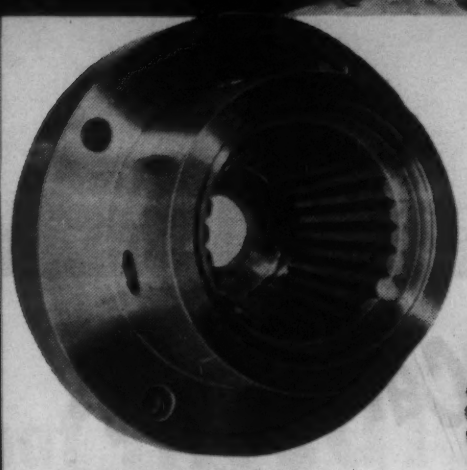
from **A** (ACETATE SOLVENT) to **Z** (ZINC CHLORIDE)

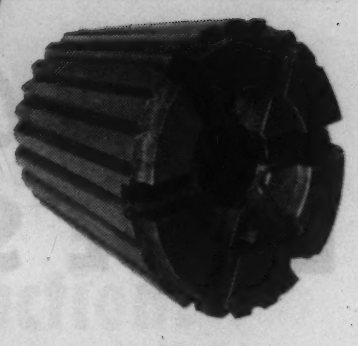


"Waukesha Metal" is a high nickel alloy — close-grained with excellent corrosion-resistant qualities. Waukesha Foundry produces castings in "Waukesha Metals" in a wide range of alloys —

- **for contact with over 100 foods, beverages, chemicals, pharmaceuticals and other products possessing corrosive characteristics.**
- **for bearing applications in equipment requiring sliding or rotational metal-to-metal contact without seizing or galling of corrosion resistant parts.**
- **for free-machining and for high polish surfacing.**

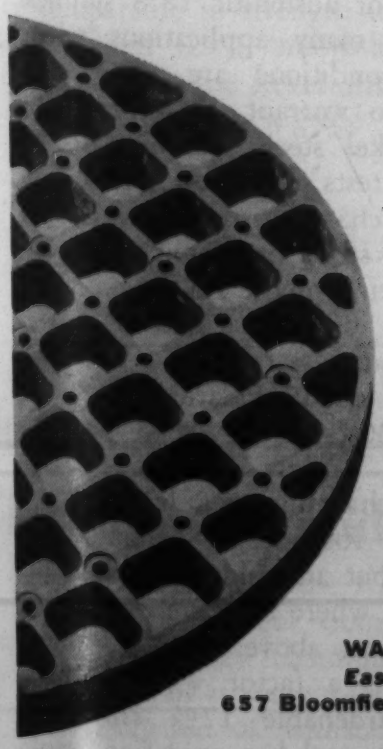
Castings in "WAUKESHA METAL" are so widely used that WAUKESHA is the largest nickel alloy jobbing foundry in the country. As just one example of the industrial acceptance of "WAUKESHA METAL" — virtually all of the milk you drink and all of the ice cream you eat has passed over a "WAUKESHA METAL" casting in processing.





WAUKESHA CASTINGS in Stainless Steel

Available in the 300-400 series . . . in extra low carbon and in the 35-15 and 25-12 high alloy series, WAUKESHA offers Stainless Steel Castings that are produced under strict metallurgical laboratory control for close texture, uniformity and dimensional correctness.



Two Booklets Available

— One booklet on physical properties, chemical specifications and application recommendations of "Waukesha Metals."

— The other booklet on WAUKESHA Stainless Steel Castings describing their metallurgical characteristics and application recommendations.

— A postcard or the convenient coupon below will bring either booklet — or both. And, of course, without obligation.

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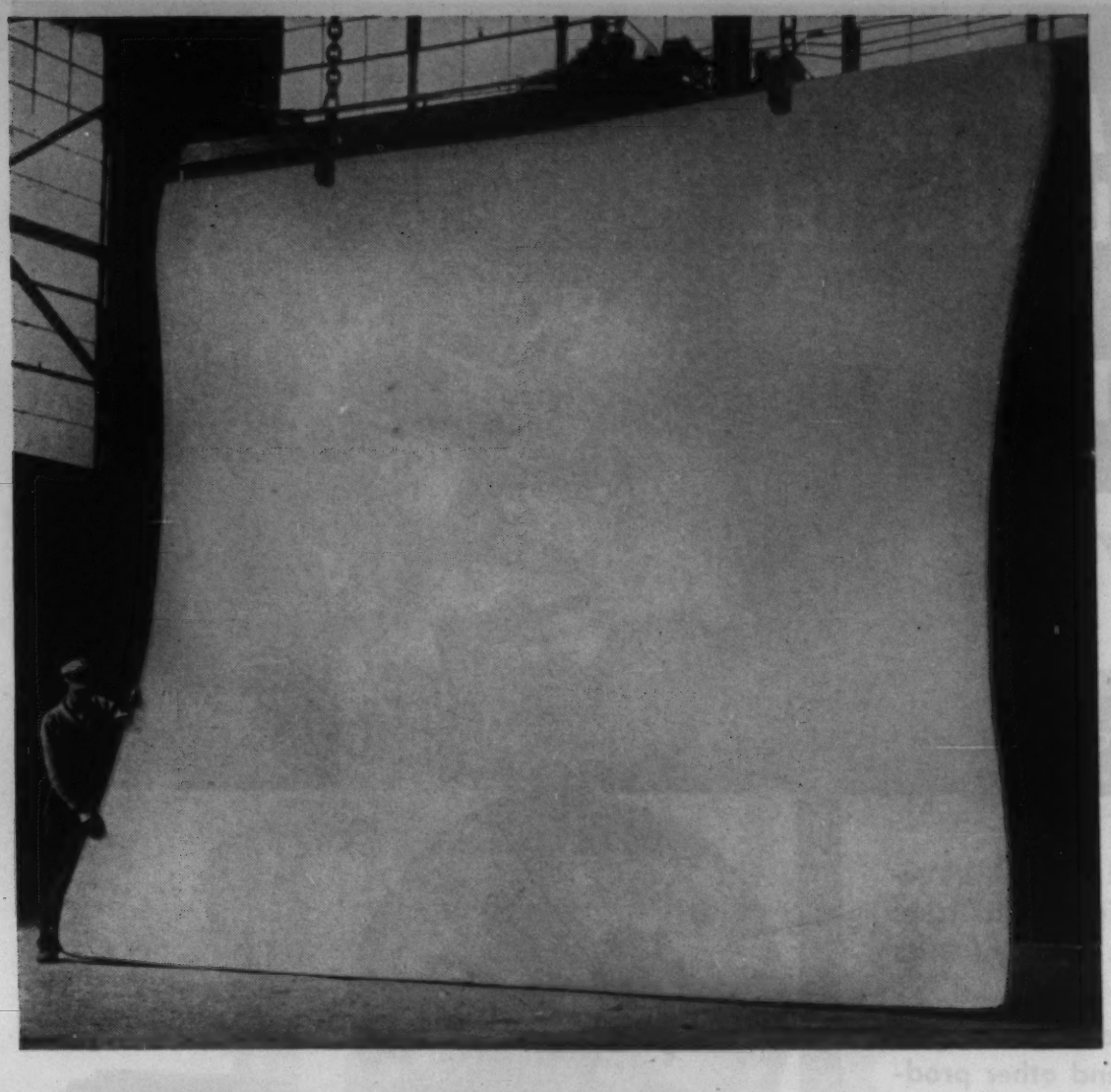

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Produced to chemical industry standards of quality, this plate, weighing 5,180 lbs., is a typical example of the ability of G. O. Carlson, Inc. to meet your needs in a wide variety of stainless analyses.

Remember too, that Carlson can supply you as readily with stainless forgings, tank heads, sheets (No. 1 Finish), bars, rings, ring blanks, flanges, etc. in *any size*, large or small. Also sketch plates cut to your specifications. Many small orders can be filled right out of stock.

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District Sales Offices in Principal Cities

News Digest

transistorized radios and television sets are under intensive development, it is probable that they will not be produced in quantity by the major commercial set manufacturers for quite some time due to high military demand for transistors and reluctance to freeze design for mass production in the face of the rapid technological progress taking place in the transistor field.

Already well established as components of hearing aids and military electronic equipment, the transistor is finding application in more and more standard and specialized equipment. The Bell System is now equipping key cities with transistorized "card translators" for the automatic routing of long distance telephone calls. A test installation of transistorized oscillators for customer long distance dialing has been in successful operation in Englewood N. J. since last October.

Observing the 5th anniversary of the development of the transistor, Bell Laboratories revealed that nearly 40 different types of experimental transistors are now under development.

Substitutes for Nickel Steel

Ferritic chromium-molybdenum or straight chromium steels may be substituted for austenitic 18:8 stainless steels in many applications where service conditions are not severe enough to warrant use of critically short nickel steel, according to results of tests on creep and creep-rupture characteristics of various substitute steels presented at the annual meeting of the ASTM.

Grades of 8% chromium, 1% molybdenum were found to have relatively good oxidation resistance up to 1300 F, but creep strength decreased rapidly above 1100 F. Higher chromium grades may be employed for greater oxidation resistance, but are seldom used in applications where they are exposed to temperatures above 1200 F, where strength is a factor.

Non-hardenable 17% chromium Type 430 steel has oxidation resist-

News Digest

nce comparable to 18:8 up to 500 F, but its low strength at elevated temperatures limits its use o applications not requiring strength nd toughness.

Addition of silicon, titanium and olumbium to the ferritic grades of teel imparts desirable properties for pecific applications; silicon increases xidation resistance, and titanium nd columbium reduce the tendency f air hardening, improving weld- bility.

Comparison of three groups of ubstitute steels with and without dditional alloying elements indicates hat the steels containing columbium re strongest up to 1200 F, but at igher temperatures the steels con- aining no additional alloying ele- ments other than molybdenum are lightly stronger.

5% chromium, 0.5% molybdenum teels with silicon or titanium are weaker at all test temperatures than he plain or columbium alloy Columbium addition to 8% chro- nium, 1% molybdenum steel in- reases strength up to 1200 F. Plain 2% chromium steels are consider- bly weaker than 12% chromium, .2% molybdenum grades with or ithout additional alloying elements.

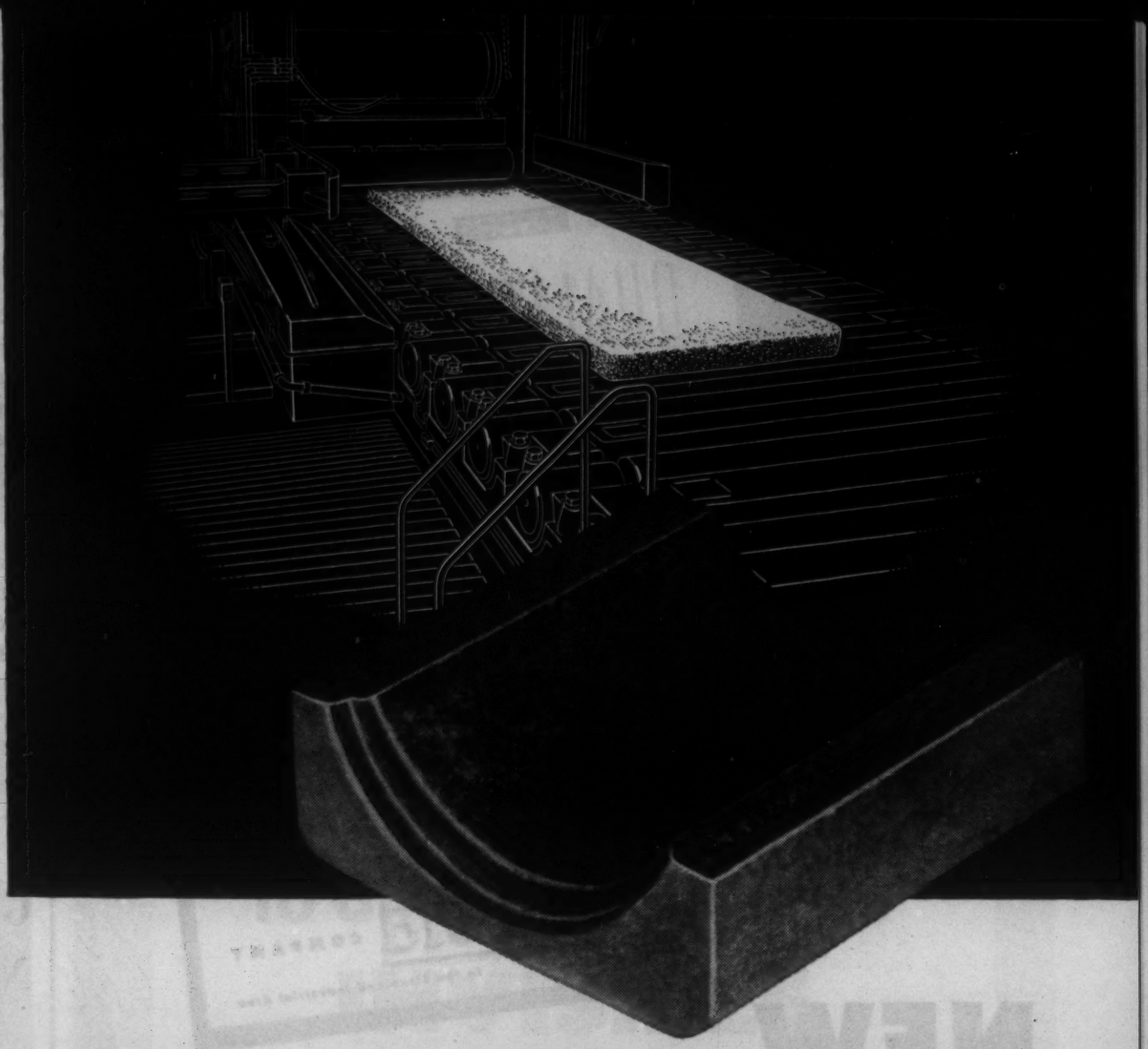
In the 12% chromium, 1.2% nolybdenum group of steels tested t 1000 F, addition of columbium dded strength. Boron-containing teel in this group was equal in reep-rupture strength, and superior n creep strength.

17% chromium steel was found o be comparable in strength to the 5% chromium 0.5% molybdenum teel, which is at the lower strength evel of the series investigated.

Stabilization of Zirconium Dioxide

Air Force scientists of the Air Research and Development Command have developed a new technique for the stabilization of zirconium dioxide, material capable of withstanding emperatures over 4000 F.

By employing special additives



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News Digest

with the zirconium dioxide, the necessary stabilization can be accomplished at lower temperatures than heretofore known. The technique will result in new fabrication methods, which will reduce manufacturing costs and make possible new utlization of this material.

Zirconium dioxide is expected to play an important role in future aircraft developments, such as in rockets, turbo-jets, and high temperature metallurgical research.

Government Sets New Tin Plate Goal

The expansion goal for electrolytic tin plate facilities has been increased from 4,100,000 to 4,500,000 net tons of annual capacity.

The move was made by the Office of Defense Mobilization in order to conserve tin by promoting greater use of the electrolytic plate. It is estimated that for every million tons of differential-coated electrolytic tin plate that replaces the same amount of hot dipped tin plate, there is a saving of about 6500 tons of pig tin.

The revised goal represents increase of 60% over the annual capacity of 2,800,000 net tons of capacity in existence on January 1, 1950.

Remote Pyrometers Speed Uranium

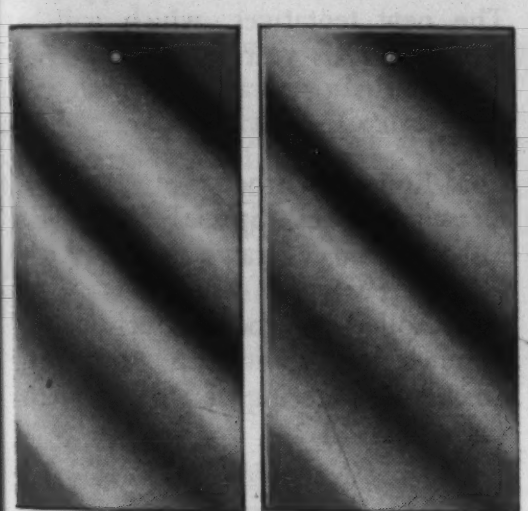
Automatic temperature monitoring units similar to those employed in steel mills have been installed in a uranium rolling mill recently built for the AEC.

In the system, radiamatic pyrometers at several points in the production line automatically pick up the temperature of the ingots and relay the information to electronic recording units in a central station,

Advertisement

Clear Lacquer Stands Salt Spray Tests for Unusual Periods

Tests conducted by an unbiased laboratory demonstrate that a transparent lacquer, already widely known for its remarkable adhesion to practically all commonly used metals, has the added advantage of exceptional durability. In these tests, the lacquer, produced by Maas & Waldstein Co. and sold under the trade name of DULAC Clear Universal Lacquer #462, was subjected to salt spray and weatherometer tests for exceptionally long periods. No sign was observed either of finish failure or of discoloration of the metal.



(Left) A zinc-coated steel panel newly coated with DULAC No. 462.
(Right) A similar panel after hundreds of hours' exposure to salt spray, showing no evidence of attack on the finish.

Typical Applications

This unusual durability of DULAC Clear Universal Lacquer #462 has led to its extensive use as a replacement for chromium or other metals normally plated of zinc or zinc-plated steel. An additional important field of application lies in the protection of chromium which because of metal shortages is being plated directly over steel, without the customary underplating of nickel-over-copper.

An air-drying coating, DULAC #462 is easily applied by dip or spray. It dries out of dust in 5 to 10 minutes, and hard in an hour. Technical Data Bulletin #110 in DULAC #462 is available from Maas & Waldstein Co., 2121 McCarter Highway, Newark 4, N. J. On request M & W Technical Service Engineers will discuss specific problems.

ADHERES
to almost any metal
INVISIBLE
on all of them
DULAC Clear Universal Lacquer #462

Here is a *single* water-white lacquer with remarkable adhesion to practically *all* metals. It's DULAC Clear Universal Lacquer #462.

Finishing shop after finishing shop* reports that this M & W lacquer can be applied with *equal* success to just about any metal—and that it's invisible when applied.

AND . . . tests conducted by an unbiased laboratory show that DULAC #462 withstands salt spray and weatherometer tests for longer periods than ordinary lacquers.

DULAC #462 forms a tough, lasting protective film that resists heat, cold, weather, stain, perspiration. It cuts down on *inventories*, because one lacquer handles so many metals. It cuts down on *production time*, because it dries out of dust in 5 to 10 minutes . . . hard in an hour. Applied by spray or dip.

*Names on request

For complete information, write for Technical Data Bulletin #110, or let our M & W technical consultant discuss your requirements privately with you.

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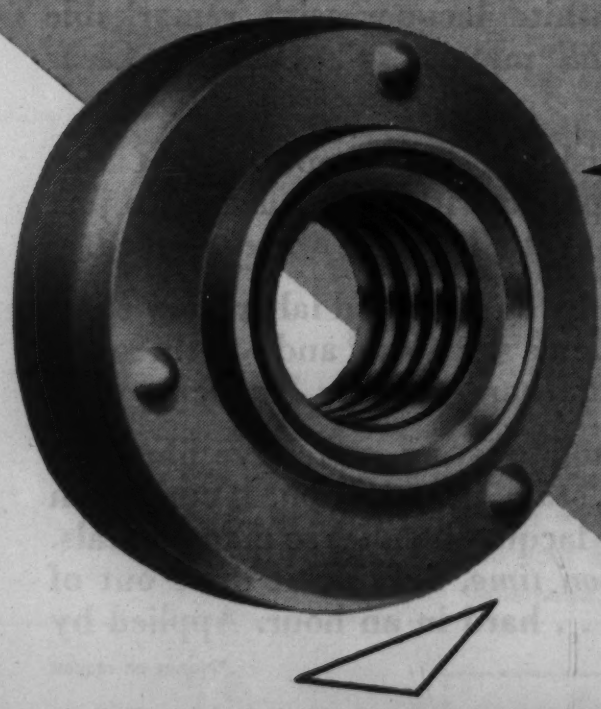

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placing all critical temperature data directly at the disposal of the rolling mill operator.

The automatic system has greater accuracy and consumes less than 1/10 the time required by conventional procedures of crayon melt temperature measuring procedures. The temperature detection system was designed for the uranium mill by Minneapolis Honeywell.

ASTM Accepts New Specifications

At the 1953 annual meeting of the American Society for Testing Materials 63 new tests and specifications for materials won society approval. The new tentatives, which will be published this year, include the following:

Steel:
Cold-Rolled Carbon Steel Deep-Drawing Sheet, Special Killed for Miscellaneous Drawn or Severely Formed Parts (A 365-53T).
Cold-Rolled Carbon Steel Sheet, Commercial Quality (A 366-53T).
Mechanical Testing of Steel Products (A 370-53T).

Cast Iron:
Chill Testing of Cast Iron (A 367-53T).

Iron-Chromium Alloys:
Stainless Steel Wire Strand (A 368-53T).

Rubber:
Non-Rigid Thermoplastic Compounds for Automotive and Aeronautical Applications (D 1277-53T).
Determining Harmful Dirt in Crude Natural Rubber (D 1278-53T).

Soaps and Detergents:
Buffering Action of Metal Cleaners (D 1279-53T).
Total Immersion Corrosion Test for Soak Tank Metal Cleaners (D 1280-53T).
Rinsing Properties of Metal Cleaners (D 1281-53T).

Adhesives:
Test for Effect of Mold Contamination on Permanence of Adhesive Preparations and Adhesive Bonds (D 1286-53T).

Reference Radiographs of:
Aluminum and Magnesium Castings (E 99-53T).

(Continued on page 205)

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Electrical Wire:
Test for Stiffness of Bare Soft Square and Rectangular Copper Wire for Magnet Wire Fabrication (B 279-53T).

Copper:
Seamless Copper Tube for Refrigeration Service (B 280-53T).

Metallic Coatings:
Preparation of Copper and Copper-Base Alloys for Electroplating (B 281-53T).

Powdered Metals:
Sintered Metal Powder Structural Parts from Brass.

Porcelain Enamel:
Test for Adherence of Porcelain Enamel and Ceramic Coatings to Sheet Metal (C 313-53T).
Test for Warpage of Porcelain Enameled Flatware (C 314-53T).

Petroleum Products:
Test for Effect of Grease on Copper (D 1261-53T).

Containers:
Test for Water Vapor Permeability of Shipping Containers by Cycle Method (D 1276-53T).

Iridium 192 Used In Radiography

Radiographic cameras using iridium 192 permit more efficient techniques for inspecting welded joints on large units. Since iridium 192 emits gamma rays of less energy than cobalt 60, less lead shielding is necessary and handling is simplified.

For Hull Inspection

A "penstock camera" using iridium 192, originally developed by Isotope Products Ltd. for inspecting joints on hydroelectric penstocks, has proved particularly useful for radiographic inspection of submarine hull welds. The camera, basically a shielded pencil of radioactive material, emits gamma rays in a narrow band of 360 deg arc. When placed at the center of a circumferential hull weld, the entire seam is covered

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✓ check the analysis
✓ check the performance

and you'll specify

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aluminum bronze

check the price—TUF-STUF, the Mueller Brass Co. series of aluminum bronze alloys, can be supplied at prices below those of similar alloys. Whether you buy TUF-STUF in rod shapes, forgings or screw machine products you'll save money because these alloys are priced right, machine better and last longer.

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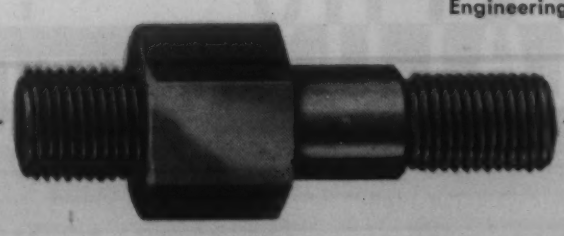

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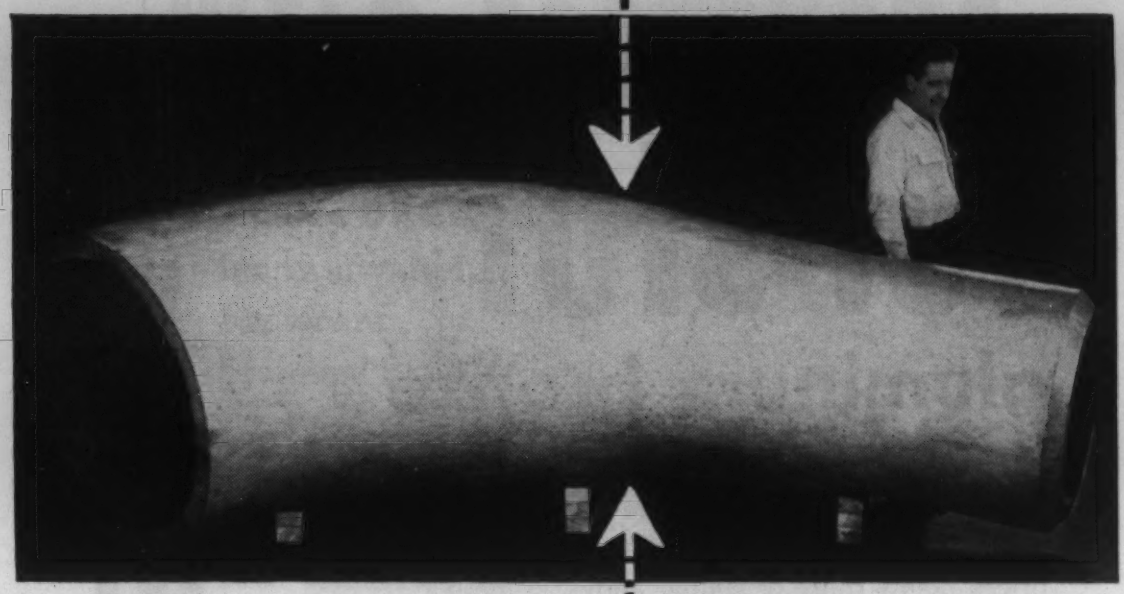
This Casting



Casting weight
21,000 pounds

Shipping weight
14,000 pounds

Alloying Elements
38% Ni., 18% Cr., 2% Mo.

Set a Record!

It's the weight rather than the Ni-Cr content that's the record.

We've cast many a piece with such a high Ni-Cr combination. But this represents the largest casting we have ever made. And it took careful scheduling of our entire battery of electric furnaces, with a double melt from two smaller furnaces.

Next followed a thorough X-ray for hidden flaws with our 400,000 volt unit. Then rough-finishing to specifications.

The significant fact is that this casting, the first of this size we have ever produced and destined for a most important high priority processing job, passed inspection with flying colors. *There was no reject here.* It is indicative of the skill of our metallurgists and foundrymen in turning out high alloy castings.

If you are looking for this kind of service, make Duraloy your casting source.

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News Digest

by a single exposure. The narrow band of radiation eliminates danger to employees working in front of or behind the camera, so work is not interrupted on other parts of the hull during inspection procedure.

Increased use of welded hulls in ship and submarine construction has necessitated greater care in weld inspection, since critical locations such as the welded crosses of merchant ships and the seams of submarine hulls must be proved completely sound.

Portable Units

Other portable or semi-portable cameras using iridium 192 which have been developed in connection with hull weld inspections include a pipe weld camera that can be used in highly restricted locations to inspect welded joints on high pressure piping after final installation, and a general purpose camera that can be carried inside hulls or large tanks by hand to spot-check welded seams.

Portable radiographic equipment utilizing lower energy sources such as iridium 192 may be expected to extend inspection facilities of increased efficiency to many on-the-job projects throughout industry.

Corrosion Engineers To Inspect Oil Equipment

The corrosion history of more than 70 pieces of equipment will be revealed at the 1953 Permian Basin Corrosion Tour sponsored by the Permian Basin Section of the National Association of Corrosion Engineers, Sept. 30- Oct. 2. Corrosion preventive measures taken and the results will be seen for each piece of equipment inspected on the tour. Operating companies will cooperate to provide equipment for inspection.

(Continued on page 208)

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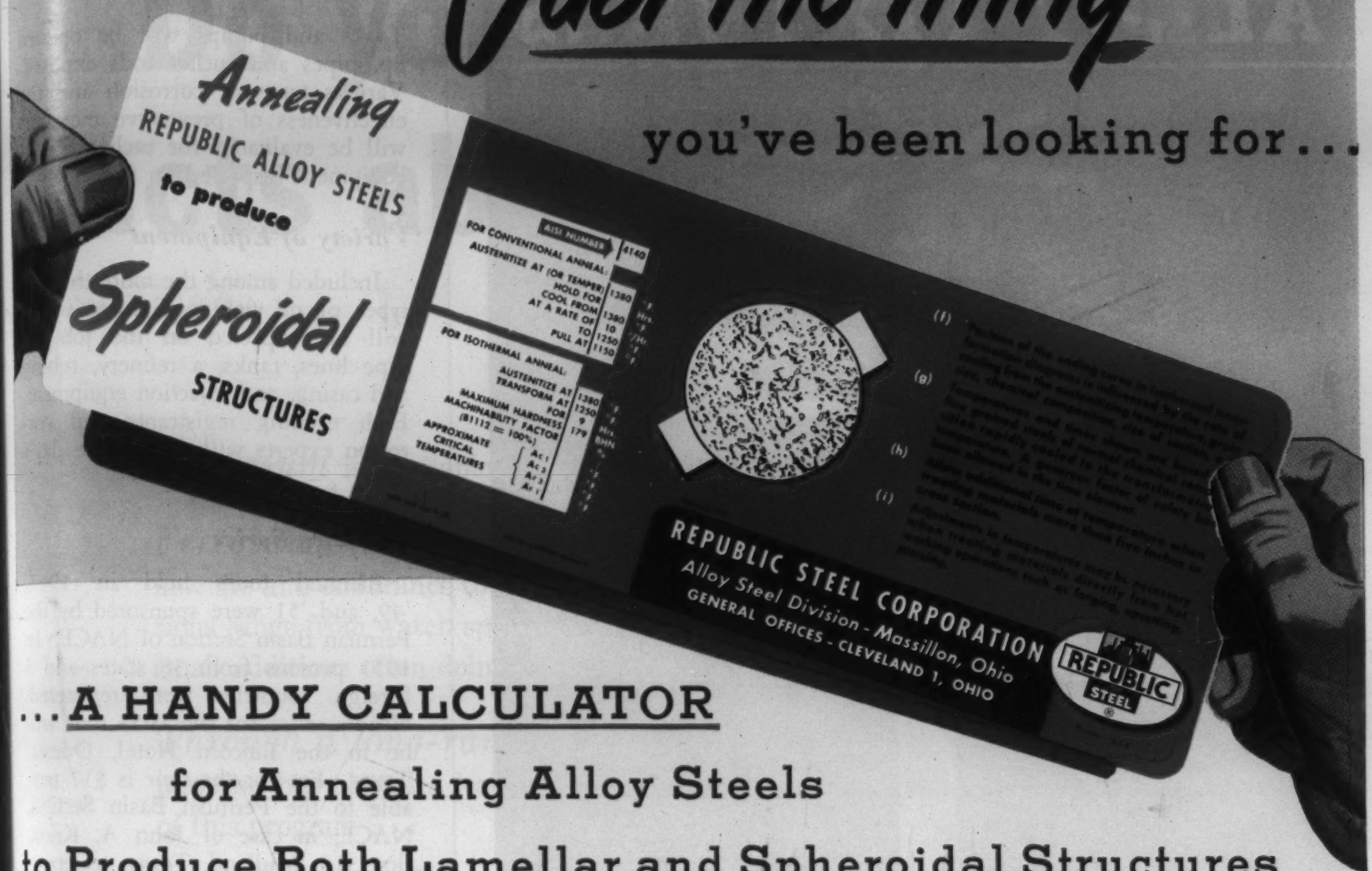

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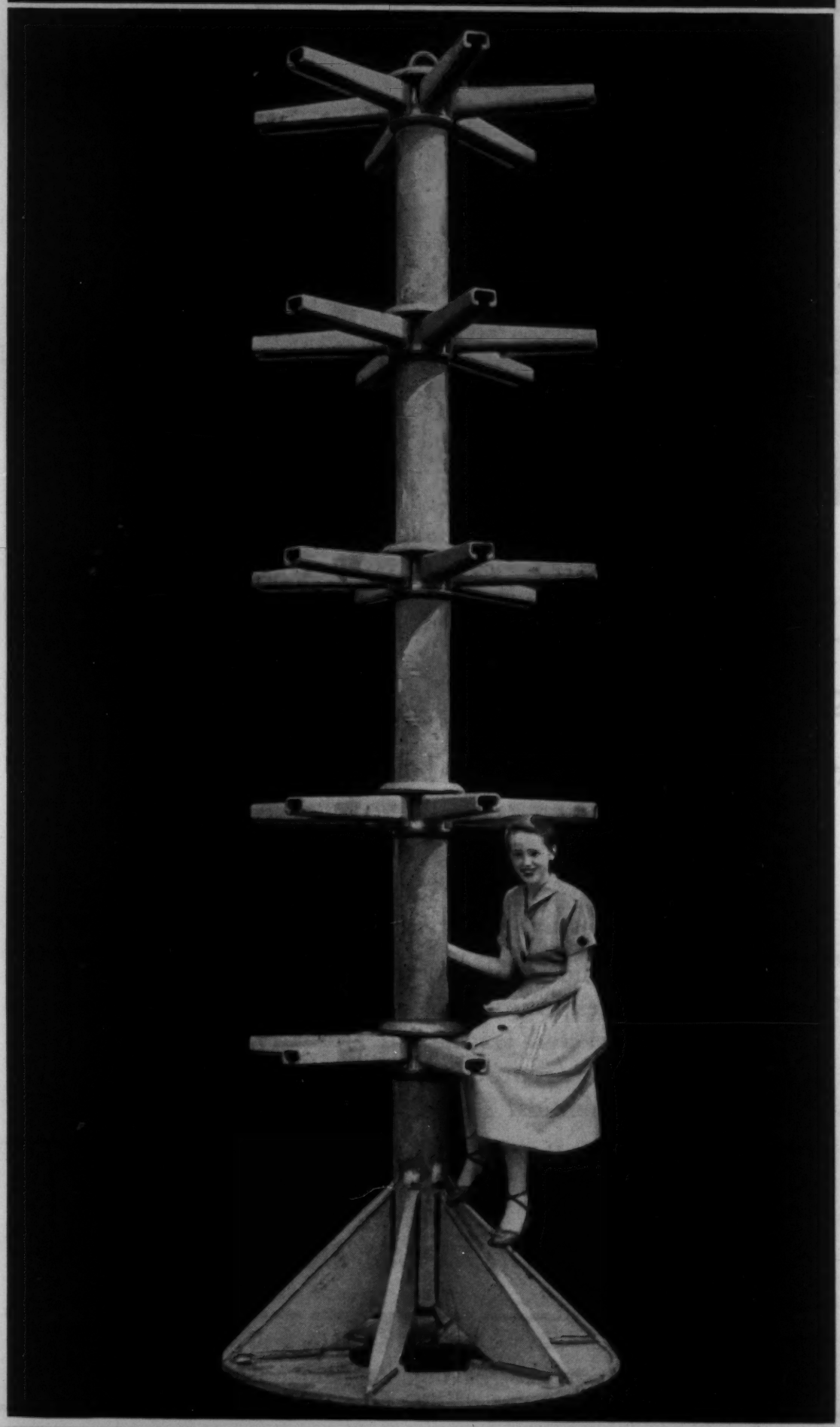

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Tanks and pumps will be opened up, pipes and sucker rods exposed. Various types of corrosion and the effectiveness of preventive measures will be evaluated for each piece of equipment inspected on the tour.

Variety of Equipment

Included among the more than 14 types of oil field equipment which will be inspected on the job are pipe lines, tanks, a refinery, tubing and casing, and injection equipment. Each evening registrants and corrosion experts will discuss the day's tour.

One of a Series

Biennial tours held in 1947, '49, and '51 were sponsored by the Permian Basin Section of NACE. In 1951 persons from 38 states and 3 foreign countries were registered. Headquarters for the 1953 tour will be in the Lincoln Hotel, Odessa, Texas. Fee for the tour is $17 payable to the Permian Basin Section, NACE, in care of John A. Knox, Box 310, Midland, Texas, secretary-treasurer of the Permian Basin Section.

New Copper Facility Casts Larger Ingots

A new copper casting plant is turning out slabs of copper weighing up to 3000 lb in a casting system using water cooled molds.

The larger slabs permit rolling mills to run longer coils of sheet which are expected to allow copper fabricators to cut machine set up time to a minimum.

The new casting facilities are part of the Raritan Copper Works of International Smelting and Refining Co., a subsidiary of Anaconda.

Casting Technique

Two new oil-fired furnaces melt the 99.95% plus electrolytic copper and feed it to molds mounted on a rotary casting table that permits al-

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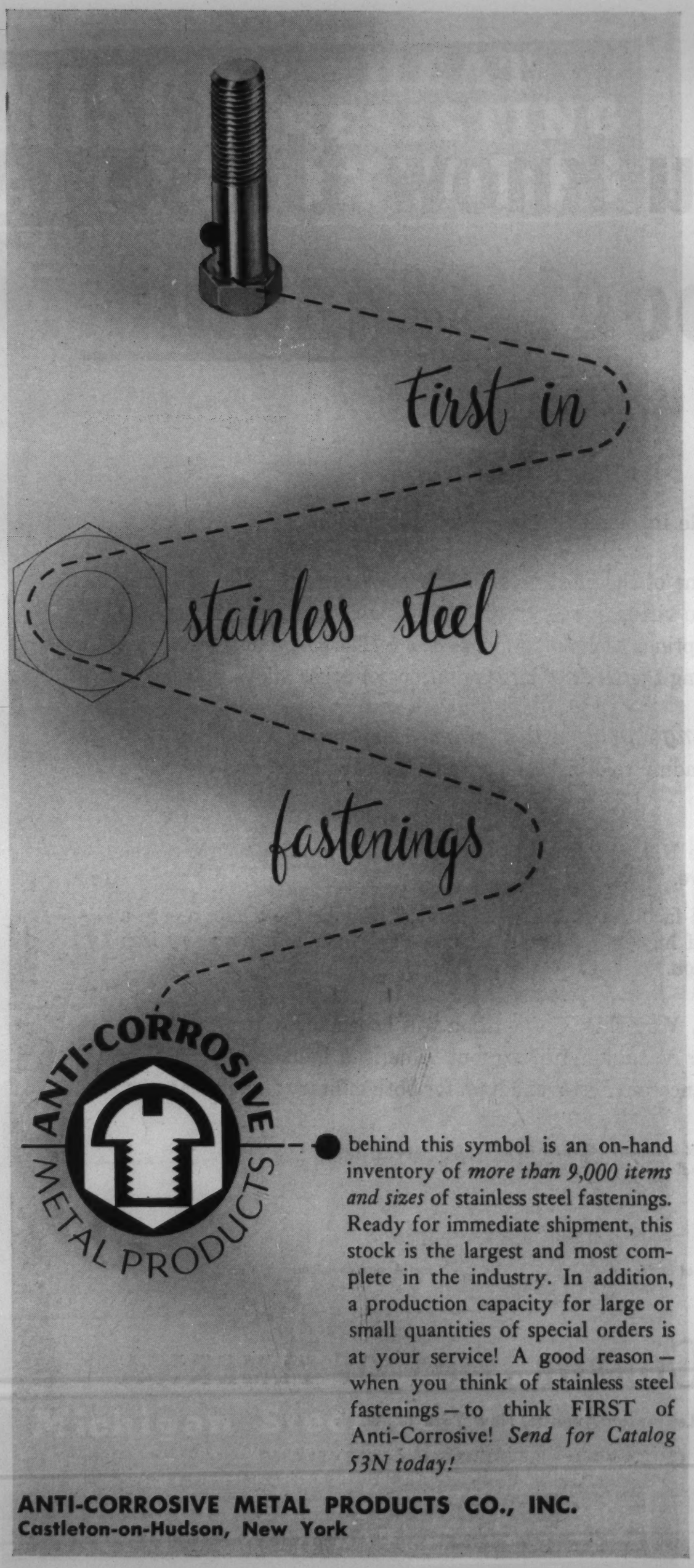

behind this symbol is an on-hand inventory of *more than 9,000 items and sizes* of stainless steel fastenings. Ready for immediate shipment, this stock is the largest and most complete in the industry. In addition, a production capacity for large or small quantities of special orders is at your service! A good reason — when you think of stainless steel fastenings — to think FIRST of Anti-Corrosive! *Send for Catalog 53N today!*

ANTI-CORROSIVE METAL PRODUCTS CO., INC.
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News Digest

most continuous pouring and cooling. There are twelve molds mounted on the table, each one separately water cooled to maintain constant temperature.

Parrallel Sided Ingots

An important feature of the new casting process is that it produces parallel sided copper slabs instead of wedge shaped ingots. Heretofore all heavy copper slabs had been cast in wedge form which necessitated a great deal of excess handling in fabrication mills. The maximum size of the wedge shaped ingots produced by the old facilities was 850 lb, so the new slabs are not only easier to handle, but are as much as seven times as large. The new ingots will enable copper fabricators to use rolling facilities similar to those used in the steel industry.

New Molds Developed

The Raritan Works reports that considerable research went into developing a suitable mold which would turn out the parallel cakes and stand up under severe operating conditions. It was found that a water cooled mold would perform properly and reduce the temperature of the casting without damaging the product if the temperature range were held within 150 to 180 F. A take-out device was also developed to remove the castings from the molds without damage.

Ingots in Several Sizes

Several sizes of molds are used, and copper slabs can now be cast in thicknesses of five inches with lengths ranging from 65 to 76 in. and widths 15½ to 24¾ in. Plant capacity was not announced, but the company gave the pouring time per ingot as two min. At that rate several hundred thousand lb of ingots per day can be produced from each of the new furnaces.

Economies Expected

The new casting plant is a direct result of demands from copper fabricators for longer coils of sheet metal. Production of larger ingots will make longer coils available and is expected to result in economies throughout the copper fabricating industry.

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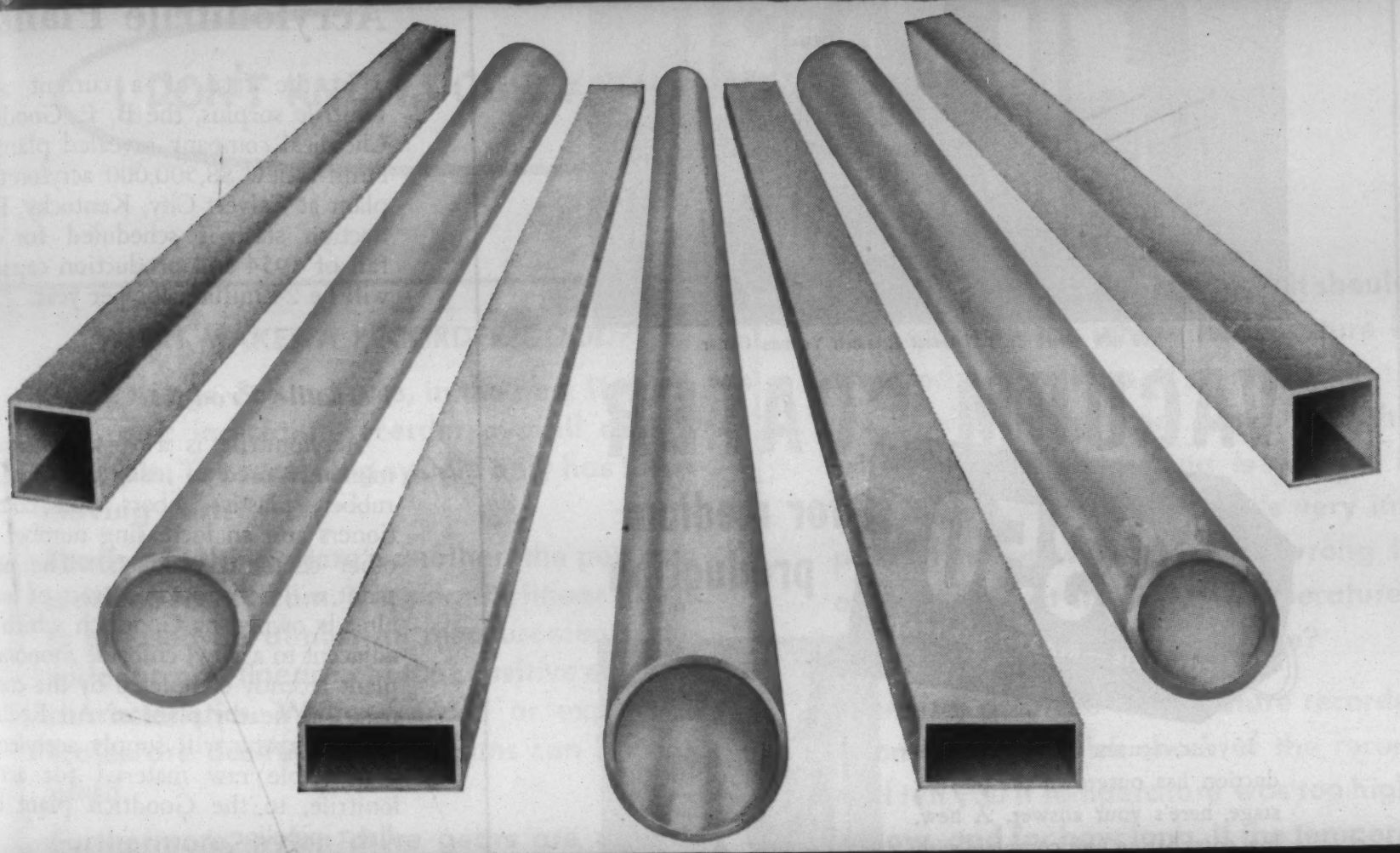

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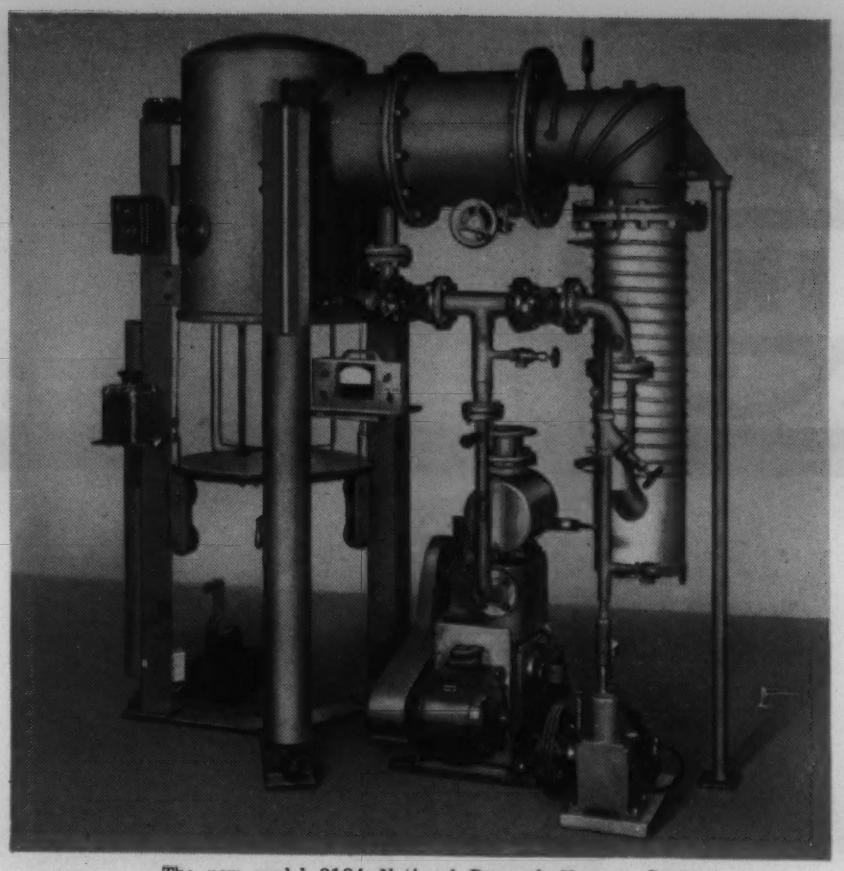

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Simple to operate. All loading, unloading and operating is done at a single station. Equipped with NRC Rotary Gas Ballast Pumps that maintain initial cfm rate even when pumping water vapor, plus a 10-inch diffusion pump. Pump down time to coating pressure is approximately 4 to 5 minutes with the tank dry and empty. Tank size 24 inches in diameter, 30 inches high. Write for details.

*F. O.B. Newton, Mass.

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News Digest

Goodrich to Build Acrylonitrile Plant

In the face of a current acrylonitrile surplus, the B. F. Goodrich Chemical company revealed plans to build a new $8,500,000 acrylonitrile plant at Calvert City, Kentucky. Production start is scheduled for the fall of 1954 and production capacity will be 24 million lbs per year.

Versatile Product

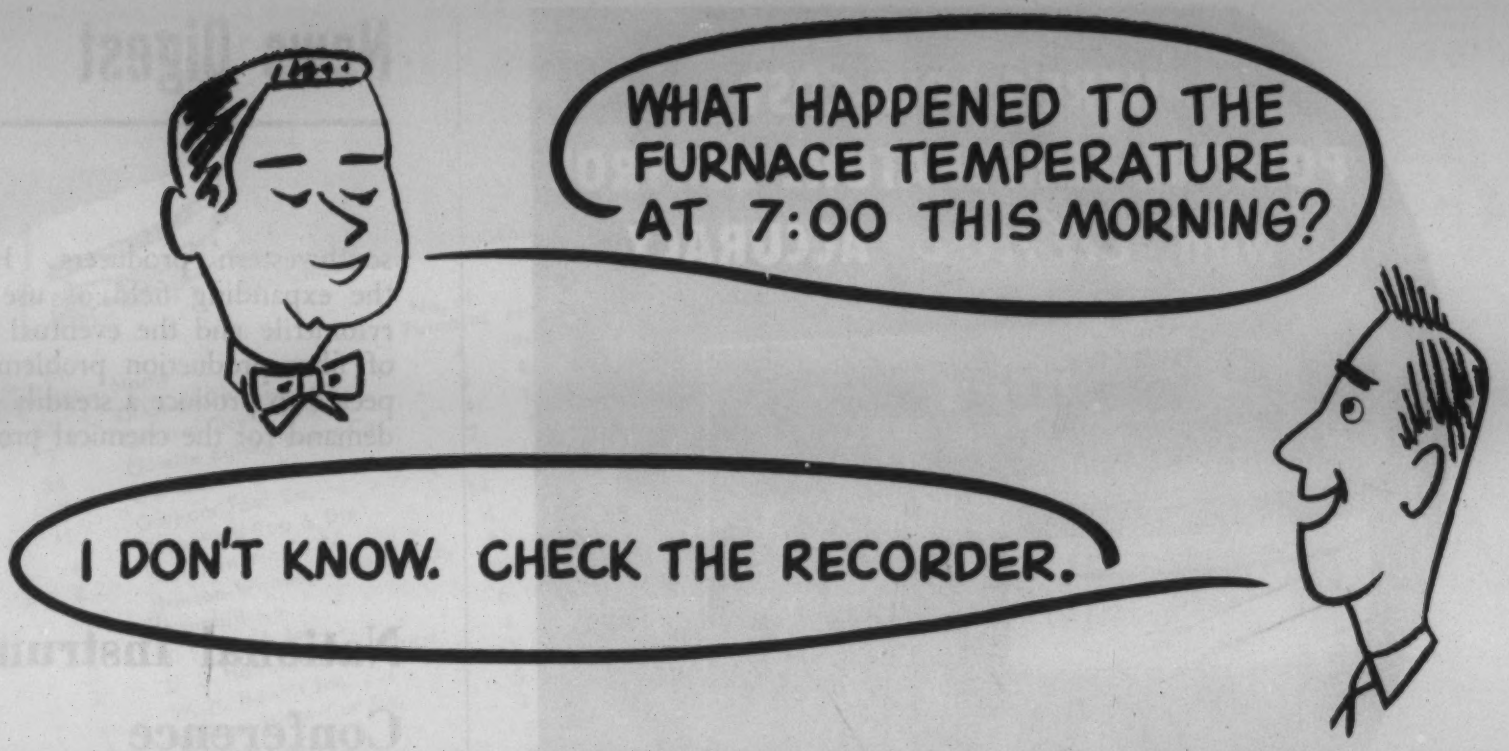
Acrylonitrile is a versatile liquid monomer used to make oil resistant rubber, plastics, fibers, soil conditioners and an increasing number of other chemical products. The new plant will be built on a tract of land already owned by Goodrich which is adjacent to a vinyl chloride monomer plant recently completed by the company. A nearby plant of Air Reduction Company will supply acetylene, a principle raw material for acrylonitrile, to the Goodrich plant by direct pipeline.

Used in Hycar Rubber

J. R. Hoover, president of Goodrich Chemical Co. said the new production facility was intended to broaden the base of the company's chemical operations, and to supply the large quantities of acrylonitrile required in the production of Hycar American rubber, a product used widely in the oil, automotive, aeronautical and adhesives industry. The decision to construct facilities for manufacturing acrylonitrile followed a long range research and development program including continuous operation of a semi works at the Goodrich Experimental Station.

Current Surplus

The Goodrich announcement came practically on the heels of news that manufacturing difficulties with acrylonitrile fibers such as Acrilan had resulted in a virtual cessation of production of acrylonitrile by some



WHAT MAKES A RECORDER GOOD?

Many things. For instance, in the new Thermo Electronic indicating-recorder overall design is simple. The recording system only has three moving parts.

That's one thing. Here's another: the pen arm is driven from a cam. This permits linear charts to be used for almost all measurements, despite the non-linearity of the sensitive element characteristics. When warped or expanded scales are desired, special cams can be supplied.

Furthermore, nylon drive gears are used to provide long life and quiet operation.

There are many other things. If you want to hear about them, let us know. We'll be glad to supply the information. Ask for Catalog No. 60 G.

AT THE ISA SHOW

This indicating-recorder, along with T-E's other pyrometric equipment, will be at the Instrument Society of America Exhibit, Sherman Hotel, Chicago, Ill., Sept. 21-25, Booth 59.

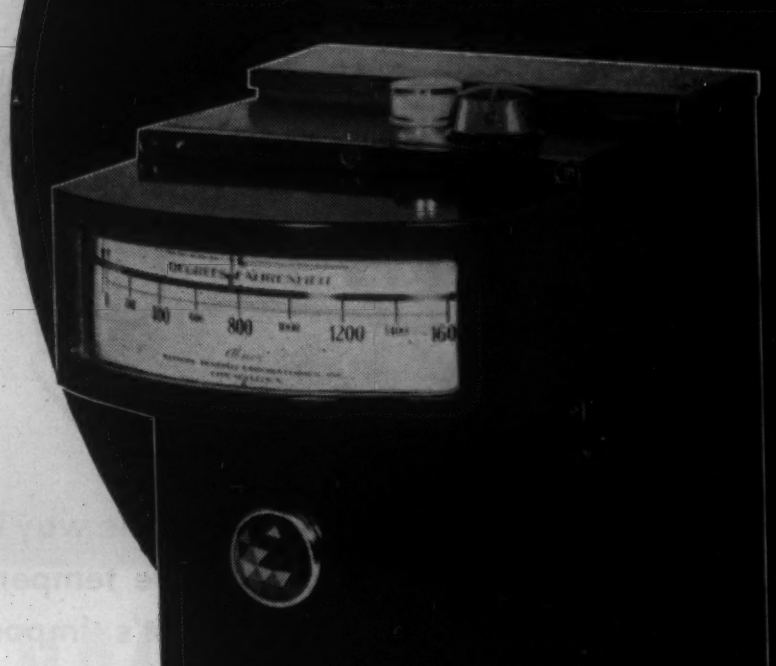
Even if everything goes the way it should with any process where temperature is involved, sometimes it's important to *prove* everything went right. On the other hand, if something is wrong, if standards aren't met, then it's very important to *know* what went wrong in order to correct it. Was it temperature? Or some other process variable?

When an accurate temperature recorder is on hand, a quick check of the record will tell you if temperature was too high, or low, and for how long. If the temperature was off, your problem is pinpointed and you can work on it right away. If it wasn't, you can go on to other variables and find the troublemaker. Either way, a good recorder is a time-saver.

Thermo Electric makes a good recorder —it is accurate (±¼ of 1% of the range), sensitive (better than ±1/20 of 1%), durable, and can be used to record variations in temperature, humidity, solution conductivity, speed, pH, direct current, DC voltage, strain, or other variables. Both potentiometer pyrometer and resistance thermometer bridge types are available, depending on the application.

Thermo Electric Co., Inc.
FAIR LAWN NEW JERSEY

HERE'S LOW-COST
POSITIVE TEMPERATURE CONTROL
with *Alnor* ACCURACY



Alnor
Temperature Controller

Now—at a cost far less than you may think—you can bring automatic precise temperature control to heat-treating furnaces, bake-ovens, etc.—in fact, to any heating device whether electrically heated or fuel fired. The Alnor Controller is simple in design and operation—you merely set the pointer at the desired cut-off temperature, and it's ready to give you the finest in accurate controller service on new or existing heating equipment. Alnor quality throughout, it features the famous double air gap pyrometer movement; easily read, 6-inch mirrored scale; automatic cold-end compensator; weather-proof, dust-tight case—a truly rugged, precise instrument at a price you can afford. Write today for complete information and price. Illinois Testing Laboratories, Inc., Room 522, 420 N. LaSalle St., Chicago 10, Ill.

Alnor

PRECISION INSTRUMENTS
FOR EVERY INDUSTRY

News Digest

southwestern producers. However, the expanding field of use for acrylonitrile and the eventual solution of fiber production problems is expected to produce a steadily growing demand for the chemical product.

National Instrument Conference

The Eighth National Instrument Conference and Exhibit of the Instrument Society of America will be held September 21 to 25 in Chicago, Ill. Technical sessions are scheduled to take place in the Morrision Hotel. Manufacturers exhibits will be in the Sherman Hotel.

Maintenance Clinic

Instrument manufacturers are providing instructors for a maintenance clinic which is scheduled for Sept. 18 through 20th, the three days preceding the actual Conference and Exhibit. Friday evening, Sept. 18, will be devoted to a general session on Principles of Instrumentation and Automatic Control.

Analytical Instrument Clinic

The Analysis Instrumentation Committee of ISA has arranged for eight leading manufacturers to conduct an Analytical Instrument Clinic which will be held continuously during the conference. The clinic will consist of a lecture and demonstration course on complex instruments such as X-ray fluorescence spectrographs, dispersion infrared analyzers, analytical computers and gas analysis.

Technical Program

Technical meetings of the various committees will be held both morning and afternoon throughout the five days of the conference.

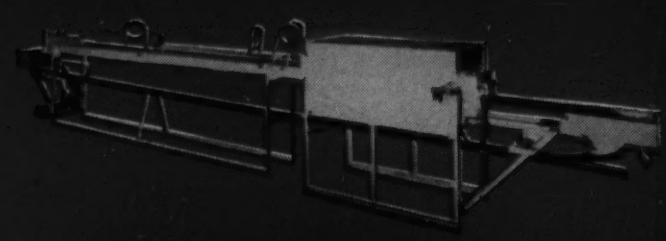
Exhibitors

Over 200 exhibitors have reserved space at the Sherman Hotel, and will have representatives on hand to provide demonstrations and information.

WHO uses Hayes "Certain Curtain" Furnaces?
Well, pretty near everybody –

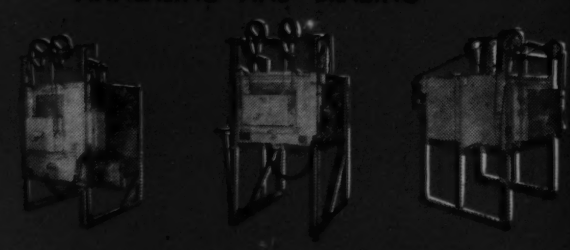
Name	No. of Furnaces
Grinnell Co.	4
General Tire & Rubber	5
Gillette Safety Razor Co.	4
Gorham Mfg. Co.	2
Gorham Tool Co.	7
Greenfield Tap & Die	14
Hamilton Watch Co.	4
Hanson-Whitney Machine Co.	3
Hemphill Co.	3
B. F. Hirsch Inc.	6
U. S. Hoffman Mach. Corp.	4
W. H. Howitt Inc.	13
Hudson Motor Car Co.	5
Hughes Tool Co.	4
Hyatt Bearing	5
Hytron Corp.	7
Int. Business Mach. Corp.	3
International Harvester Co.	11
Jack & Heintz Co.	13
Jones & Laughlin Steel Corp.	10
Jones & Lamson Co.	3
Walter Kidde Co.	3
Kollsman Instrument Co.	6
Koppers Co.	2
Lamson & Sessions	5
Lansdale Tube Works	10
D. E. Makepeace Co.	7
Marion Steam Shovel Co.	3
Mass. Inst. of Technology	7
McCord Radiator & Mfg. Co.	4
Mergenthaler Linotype Co.	7
Merriman Bros.	4
Michigan Tool Co.	5
Moraine Products	5
Morse Twist Drill Co.	3
Nat. Bureau of Std.	2
Nash Kelvinator Corp.	4
Nat. Cash Register Co.	2
Nat. Supply Co.	6
Nat. Union Radio Corp.	11
New York Central System	3
Ohio State University	4
Ohio Steel Foundry	6
Oldsmobile Motor Works	4
Packard Motor Car Co.	11
Penna. R. R. Co.	3
Permanente Metals Corp.	3
Pittsburgh Commercial Heat Treating	4
Pratt & Whitney	13
Pressed Steel Car Co.	3
Pullman-Standard Car Mfg.	8
Radio Corp. of Am.	8
Raytheon Corp.	7
Remington Arms Co.	4
Remington Rand, Inc.	5
Republic Aircraft Products	9
Republic Drill & Tool Co.	18
Republic Steel Corp.	8
Reynolds Metals	9
Robertshaw-Thermostat Co.	4
Russell, Burdsall & Ward Bolt & Nut Co.	8
Scintilla Magneto	8
Scott & Williams	8
Simonds Saw & Steel	3
Singer Mfg. Co.	3
J. T. Slocomb	6
J. K. Smit & Son, Inc.	7
Southern Textile Machinery Co.	4
Speidel Corp.	5
Sperry Gyroscope	12
Std. Pressed Steel Co.	5
Std. Tool Co.	10
L. S. Starrett Co.	10
Steel Improvement & Forge Co.	6
I. Stern & Co.	4
Stone & Webster Co.	8
Sylvania Electric Products Inc.	48
Ternstedt Mfg. Co. Div.	8
Thompson Products, Inc.	47
Timken Roller Bearing Co.	9
Tomkins-Johnson Co.	4
Torrington Co.	5
Tubular Rivet and Stud	6
Tung-Sol Lamp Works	4
Uncas Mfg. Co.	6
Underwood Elliott Fisher Co.	4
Union Twist Drill	18
U. S. Government	150
U. S. Army, Navy and Air Force	350
University of California	5
Universal Trading	13
Universal Winding	3
Utica Drop Forge & Tool Corp.	4
Weldon Tool Co.	4
Western Electric Co.	4
Westinghouse Elec. & Mfg. Co.	3
Whitman & Barnes	4
H. A. Wilson	5
Williams & Wilson	18
Wire Stitcher Co.	2
Mfg. Co.	10
-Lipe Chapin Div. GMC	7
n & Sharpe Mfg. Co.	15
Motors	8
va Watch Co.	18
negie Illinois Steel Corp.	14
ass, Brass & Copper Co.	3
evrolet Motors	10
icago-Latrobe Twist Drill	8
hrysler Corp.	14
Cleveland Cutter & Reamer	5
Clinton Engineer Works	5
Commercial Steel Treating Corp.	12
Crucible Steel Co. of America	5
Denver Fire Clay Co.	5
Dept. of Commerce	2
Detroit Steel Treating	3
Dow Chemical Co.	5
Eastman Kodak Co.	23
Easy Washing Mach. Co.	4
Eclipse Aviation	11
Eclipse Machine Division	4
Thomas A. Edison, Inc.	4
Elliott Company	5
Evans Case Company	4
Ex-Cello Corp.	13
Fisher Body Corp.	6
Ford Motor Co.	73
Frankford Arsenal	6
Frigidaire Corp.	21
General Electric Co.	35
Division	15
	7
of America	34
dlum Steel	8
ss Co.	11
n Company	4
r & Foundry Co.	2
Optical Company	14
teel & Wire Co.	8
Machine Co.	3
nes Co.	4
& Co.	4
Works	4
hone Labs.	10
Aviation	6
m Steel Co.	66
luminum and Brass	11

This list shows some of the Hayes furnace users, serving to give you a good idea of their wide acceptance.

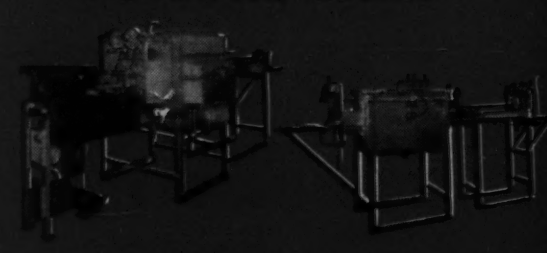


CONVEYOR SINTERING, SOLDERING, COPPER BRAZING, ANNEALING, ETC.

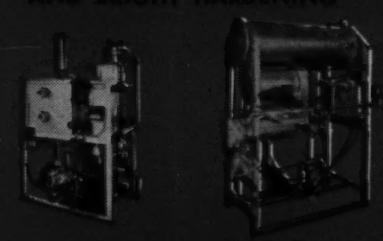
STAINLESS BRIGHT HARDENING, ANNEALING AND BRAZING



HARDENING AND TEMPERING



COPPER BRAZING, SOLDERING, SINTERING AND BRIGHT HARDENING



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AMMONIA DISSOCIATOR

It pays to have the BEST in Heat-Treating Equipment. Hayes offers you the world's leading controlled-atmosphere equipment . . . plus Hayes LAB to prove performance on your samples and pre-insure your purchase . . . plus 48 years' KNOW-HOW that follows through to make sure you receive satisfaction.

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ELECTRIC CERTAIN CURTAIN FURNACES

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Denver 15, Colorado

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Chicago, Ill.

JOHN E. HOMER CO.
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Birmingham, Ala.

DAY ENGINEERING CO.
27 Rittenhouse Place
Ardmore, Pa.

J-M BLAZECRETE speeds refractory repairs...

That's why it pays you to use this hydraulic setting refractory for temperatures to 3000F.

REPAIR old refractory linings—or build new ones—quickly and economically with Blazecrete*. For troweling, just mix Blazecrete with water as you'd mix ordinary concrete . . . then slap-trowel it in place.

When gunned, it adheres readily with a minimum of rebound loss. Either way, Blazecrete goes on fast . . . without laborious ramming or tamping. *And Blazecrete linings last.*

Three types of hydraulic-setting Blazecrete are available. All harden on air curing, do not require prefiring. They are furnished as a dry mix . . . can be stored safely for use as needed.

3X BLAZECRETE—For temperatures through 3000F. Unusually effective for heavy patching, especially where brickwork is spalled or deeply eroded. Excellent for forge furnace linings, lime kilns, burner blocks, soaking pits, and industrial boilers.

STANDARD BLAZECRETE—For temperatures through 2400F. Makes repair work easier and less costly. Can be used by boiler manufacturers to replace fire clay tile in wall construction. Suitable for use in combination with 3X Blazecrete and L. W. Blazecrete.

L. W. BLAZECRETE—For temperatures through 2000F. An insulating refractory . . . light in weight, low in thermal conductivity. Adaptable and economical for many other applications.

Send for Brochure RC-28A on Blazecrete and its companion material, Firecrete*. . . the hydraulic setting castable refractory for making special shapes and linings. Write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ontario.

*Reg. U.S. Pat. Off.

Whether you gun it... *or slap-trowel it...*

Johns-Manville **BLAZECRETE**

BUILDS BETTER REFRACTORY LININGS

News Digest

Registration

Members of the ISA, AIEE, ASME, SAMA and exhibiting companies may attend all sessions without payment of a fee. For all others, a registration fee of $3.00 must be paid on registration to attend technical meetings. There will be no charge for visiting the exhibits.

News of Engineers

Clarence N. Ferguson has joined Bjorksten Research Laboratories as a research chemist. Mr. Ferguson will do exploratory work on new types of glass-filled resin structural materials.

Stuart Brown, Jr., formerly general manager of the Suydam Div., Pittsburgh Plate Glass Co., has been named divisional manager of the M. B. Suydam Div.

Gerald Reinsmith, formerly chief of the Non-Metallic Structural Materials Unit, Office Chief of Ordnance, Dept. of the Army, has joined Narmco Industries as its Washington, D. C. office manager.

Dr. D. Gardner Foulke has been appointed manager of electrochemical development at Hanson-Van Winkle-Munning Co. Dr. Foulke will be in charge of the laboratory phase of research and development work.

J. Carlton Ward, Jr. has been elected president of Vitro Manufacturing Co. and Vitro Chemical Co. Mr. Ward has also been made a director of the companies.

M. W. Townsend, sales manager, Handy & Harman, has been appointed assistant to the president.

The Damascus Tube Co. has announced the appointment of *Byron B. Burd* as metallurgist. Mr. Burd will also be in charge of product inspection.

United States Steel Corp. has announced the following appointments: *George A. Fort* and *Eugene C. Kennedy* as division superintendent and assistant division superintendent, respectively, at the Gary Works coke plant; and *James J. Dalton* as division superintendent in the Cold Roll Div. at American Steel & Wire's Cuyahoga Works.

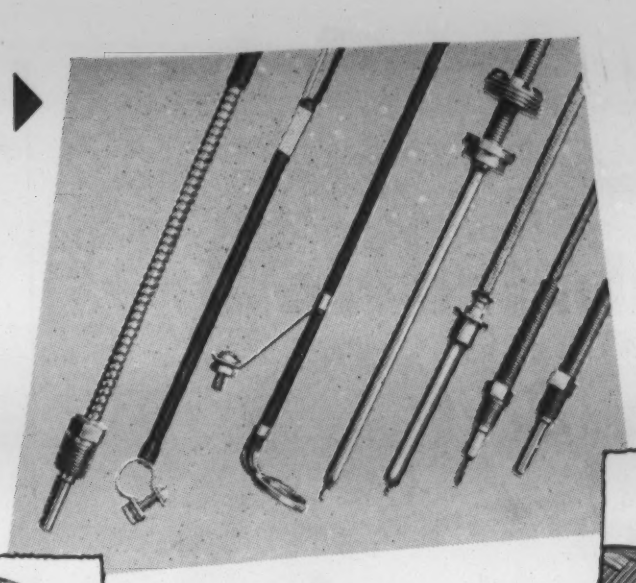
William G. Gerstacker has been ap-

THERMOCOUPLES

Revere manufactures all types of thermocouples for aircraft and industrial applications such as Moulding Presses, Oil Temperature, Cylinder Head Temperature, Fire Detection Systems, etc.; in Iron-Constantan or Chromel-Alumel.

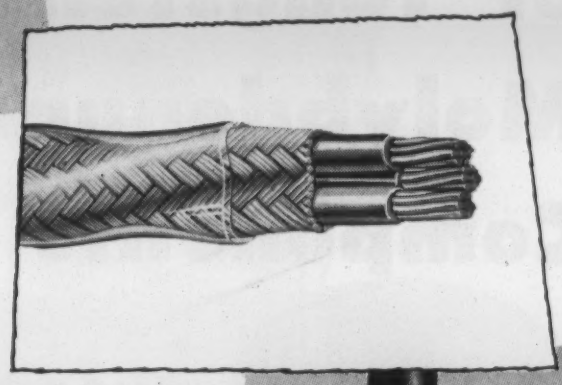
HARNESSES

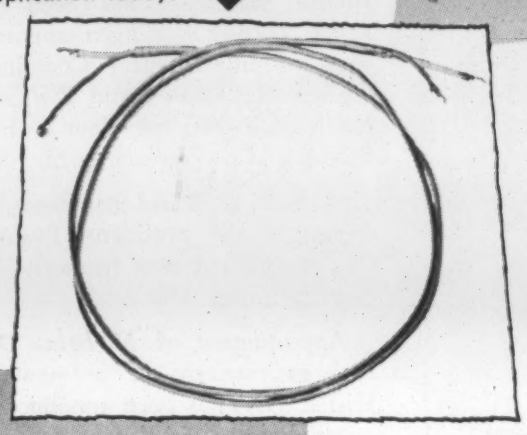
Flexible, semi-rigid, and rigid harnesses are custom-made by Revere for virtually all aircraft engines and test stand operations and for many industrial uses. Submit your special harness application today.



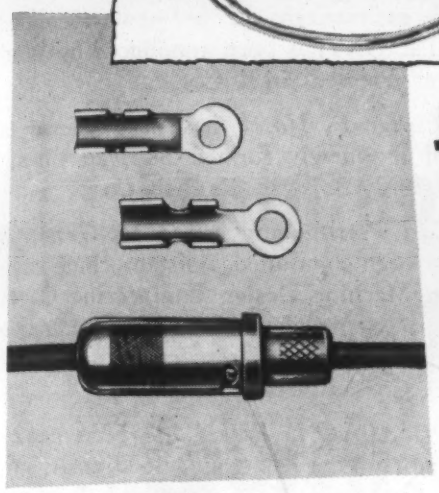
THERMOCOUPLE WIRE

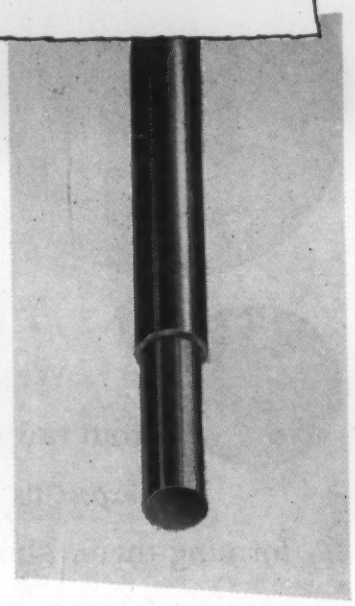
Stranding, wrapping, twisting and asbestos serving equipment enables Revere to produce thermocouple wire with cotton, glass, stainless steel, tinned copper and silver plated copper in accordance with AN and MIL Specifications.





for more accurate temperature readings contact Revere ...your dependable source of supply





CONNECTORS

Thermocouple Adapters, Terminals, Fire Wall Connectors and Resistors are manufactured in accordance with AN-5540-2 and AN-5541-1 specifications. All are ruggedly constructed to guarantee long life under hard usage.

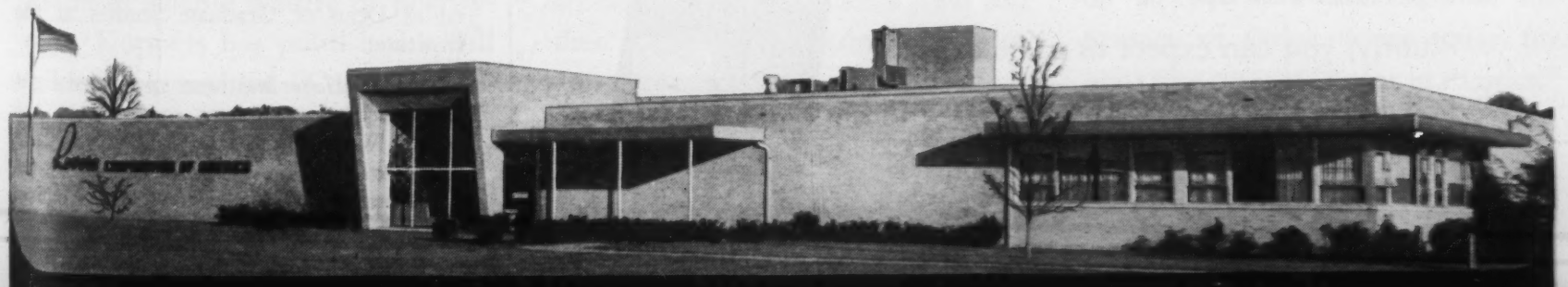
SEND FOR FREE BULLETINS!

EXTRUDED PLASTIC WIRE

A new high temperature thermoplastic insulation extruded over wires of all types, developed for use in hermetically sealed equipment or hot wiring jobs. Available in 14 colors.

Accuracy—dependability—long life are three necessary attributes of temperature measurement equipment. On all 3 counts Revere products have established unsurpassed performance records. Recognition of their quality by the government and industry has made Revere one of the foremost producers of thermocouples, thermocouple wire, harnesses, plastic-insulated wire, and accessories!

Revere's modern plant is capably staffed and equipped to offer complete and efficient service to all your temperature measurement requirements. Many standard stock items are available for immediate shipment. Special orders can be handled without delay. For more detailed information write to Revere Corporation of America, Field Engineering, Dept. 1, North Colony Road, Wallingford 2, Connecticut.



REVERE CORPORATION OF AMERICA

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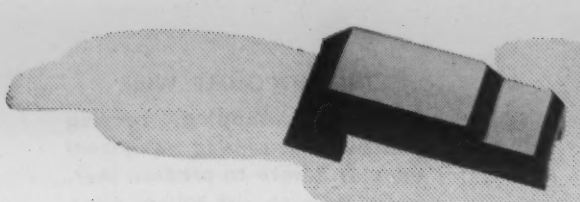
precision instruments for aircraft and industry



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We MAKE both Tungsten and Molybdenum. From raw ore to finished ingot, bar, rod or sheet, you can *expect* us to know more about these metals—about forming them, about stamping, bending, deep drawing, machining, forging, brazing or welding them.

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You can *expect* us to arrive at the best way of making your component, to produce it at the least cost—to guarantee you, when we do your fabrication, against the vagaries of rejects, scrap loss, equipment and personnel tie-up.

Bluntly, you can expect us to be experts. For, in all modesty, that's just what we are. And our experience is yours for the asking.

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"FANSTEEL TUNGSTEN AND MOLYBDENUM"

FANSTEEL
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Fansteel Metallurgical Corporation NORTH CHICAGO, ILLINOIS, U.S.A.

News Digest

News of Engineers (cont.) . . .

pointed chief engineer at Heil Process Equipment Corp.

The election of *Neele E. Stearns* and *William G. Caples* as vice presidents of Inland Steel Co. has been announced. *L. B. Hunter* has been appointed president of Inland Steel Container Co. to replace Mr. Caples, and *William A. Jahn* has been named president of Inland Steel Products Co., replacing Mr. Stearns.

Donald R. Ward has been named assistant to the president, Evans Products Co. Mr. Ward was formerly director of manufacturing schedules.

Appointment of *Nicholas D. Vuyosevich* as manager of its newly acquired Hi-Pac Div. has been announced by Worcester Pressed Steel Co.

Walter F. Hosek has been named to head the newly formed Sullivan Chemicals Div., Sullivan Varnish Co.

Carl Persson and *Hugo H. Gustafson* have been appointed assistant chief engineer, Machine Design Engineering Dept., and assistant chief engineer Production Engineering Dept., respectively, at Acme Steel Co.'s Riverdale plant.

Dr. Alfred L. Peiker has been named director of the Development Div., American Cyanamid Co.'s Stamford Research Labs. Dr. Peiker replaces Dr. L. P. Moore who was recently made assistant general manager of the Plastics and Resins Div.

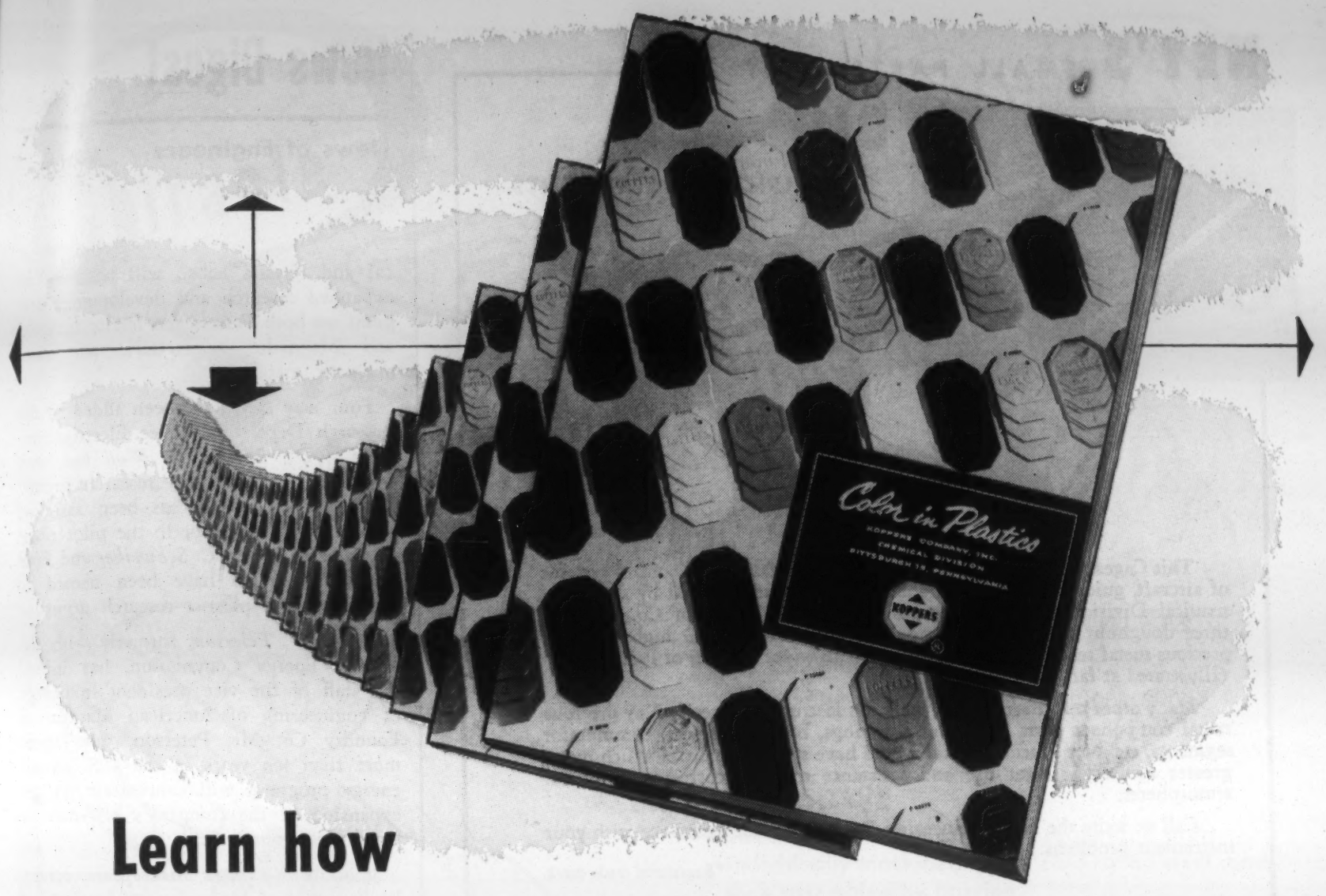
J. W. Campbell has been named assistant works manager of the Colorado Fuel and Iron Corp.'s Wickwire-Spencer plant. Since 1950 Mr. Campbell has been wire mill superintendent of the Buffalo plant.

Appointment of *Harry D. Wilson* as vice president and member of the directing board of Borden Co.'s Chemical Div. has been announced.

Dr. Robert F. Mehl, head of the Metallurgical Engineering Dept. and Director of the Metals Research Lab., Carnegie Institute of Technology, has been appointed as Dean of Graduate Studies at the Institute.

Thomas Hayes has been appointed light mechanical development manager at the Boston Woven Hose and Rubber Co. Mr. Hayes will be in charge of research and development of such products as friction tape, matting, treads, packing, etc.

Dr. L. J. Brady has been appointed director of research of the Ferroxcube Corp. of America. Dr. Brady, formerly assistant manager of the Process Development Dept., General Aniline and Film Corp., and previously head of the Technical Service for the Air Reduction Co. and in charge of their Research Analyti-



Learn how Koppers controls polystyrene's fourth dimension — Color!

COLOR is polystyrene's fourth dimension . . . with Koppers polystyrene you can specify the color of your plastic product with the same exactness with which you determine its length, width and thickness.

To help you take full advantage of the most salable feature of polystyrene, Koppers has published a full color book entitled "Color in Plastics." This unique book explains why Koppers polystyrene is visually identical in color from one lot to another over any period of time. This means you are assured of uniform colors in each similar product from first to last; and in products which are molded in two or more parts and then assembled into complete units, you can expect a uniform color match in the several sections.

Most important of all, it means that Koppers can match perfectly any shade of color you are using. If you can see it, we can match it!

For more details about Koppers unique system of color matching, and an authoritative discussion of the Science of Color, write today for your free copy of "Color in Plastics."

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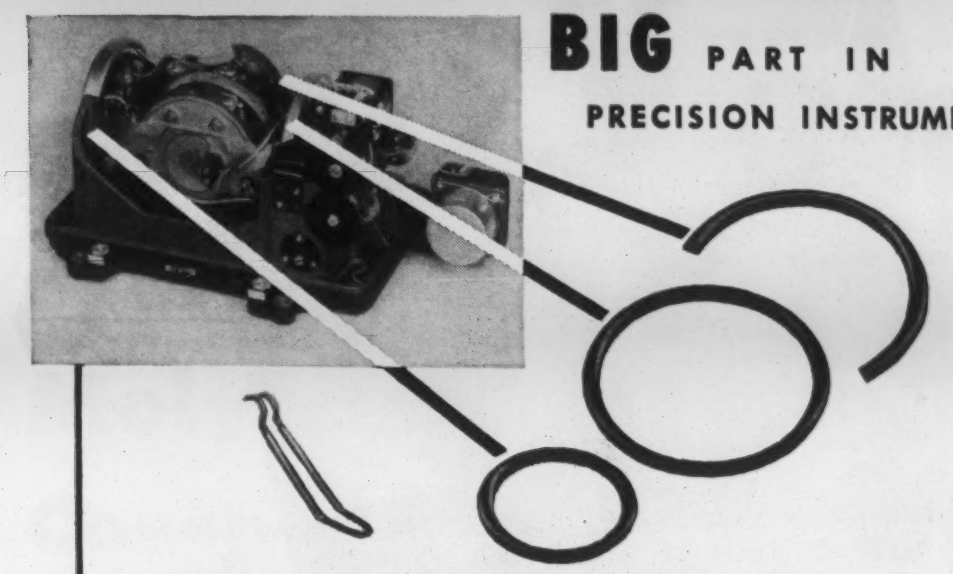
NEY'S SMALL PARTS PLAY A **BIG** PART IN PRECISION INSTRUMENTS



This Cageable Vertical Gyro, for use in stabilization and control systems of aircraft, guided missiles and radar scanners, manufactured by the Aeronautical Division of the Minneapolis-Honeywell Regulator Co., contains three doughnut potentiometers wound with NEY-ORO G high strength, precious metal resistance wire, contacted with wiper brushes of Paliney #7* (illustrated at far left).

Many other manufacturers of precision instruments specify Ney precious metal component parts for use as slip rings, brushes, wipers, commutator segments, etc. Ney Precious Metal Alloys have specific qualities which mean greater accuracy, longer life and resistance to most corrosive industrial atmospheres.

Call or write the Ney Engineering Department for assistance with your instrument problems.

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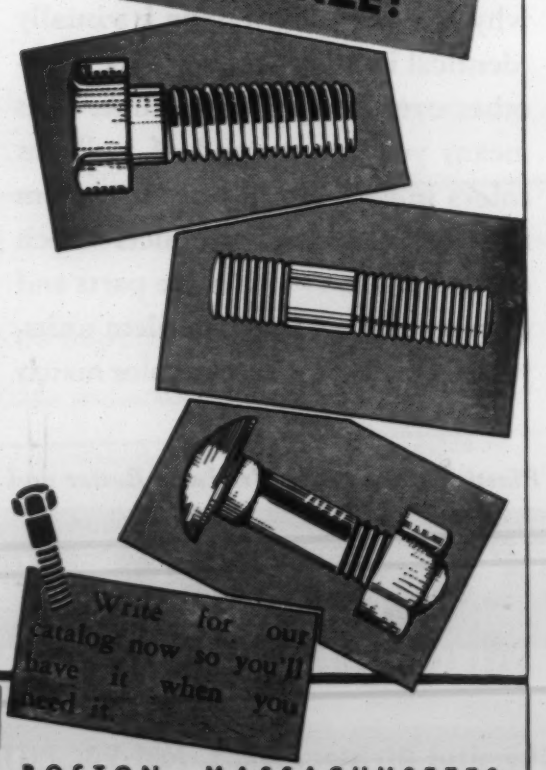
FOR THOSE FASTENERS YOU NEED THAT *MUST* BE RIGHT—

SPECIFY **JAQUES** ALUMINUM BRASS AND BRONZE!

When high standards dictate the fastening of aluminum with aluminum, JAQUES nuts, bolts, screws, etc., are the answer. Cold-headed and heat-treated, JAQUES aluminum fasteners are light, strong, and durable.

All non-ferrous metals and alloys, incuding naval brass, silicon bronze and monel, can be furnished in standard and special parts.



JAQUES Company

161 BATTERYMARCH STREET, BOSTON, MASSACHUSETTS

News Digest

News of Engineers (cont.) . . .

cal and Physics Labs., will head up an expanded research and development program on both Ferroxcube ferrite material and Magnadur nonmetallic permanent magnetic materials.

Four new men have been added to the Research Dept. of Hooker Electrochemical Co. *Dr. Edward D. Weil* has been assigned to the process research group; *Richard G. Gardella* has been assigned as a chemical engineer to the pilot plant group; *Dr. George C. Schweiker* and *Finn Claudi-Magnussen* have been named to the resins and plastics research group.

Arthur V. Peterson, formerly with the Atomic Energy Commission, has joined the staff of the vice president in charge of engineering of American Machine & Foundry Co. Mr. Peterson, who spent more than ten years in the U.S. atomic energy program, will concentrate on the expansion of the company's activities in the atomic energy field.

William MacIntyre Shakespeare, ceramist, formerly of Massachusetts Institute of Technology, has joined the Glenco Corp. as ceramic engineer in charge of a group for development of new ceramic compositions and new casting techniques.

C. I. Bradford has been appointed vice president and director of operations, and *W. E. Gregg* has been appointed assistant director of operation of Rem-Cru Titanium, Inc.

Promotions of *Fred Terens* and *Ralph Paddock* to newly created positions at the Aluminum Goods Mfg. Co. have been announced. Mr. Terens is the newly appointed manager of manufacturing and will be responsible for the purchasing and manufacturing of all tools, dies, machines and equipment as well as for the manufacturing procedures in all plants. Mr. Paddock has been named manager of quality control and finishes and will be in charge of all methods of finishing and applications of finishes. Chemical, physical and metallurgical testing, and the inspecting and quality control of all manufactured or purchased parts also come under his control.

James L. MacDowell, a veteran of 20 years of service with Standard Pressed Steel Co., has been made manager of tooling and quality at the company. Mr. MacDowell moves up from superintendent of the Automatic Screw Machine Dept. to replace *Albert A. Leedom,* who has been assigned to the staff of Cooper Precision Products, an SPS subsidiary.

F. Richard Meyer III has been named as assistant to the president, Acme Steel Co.

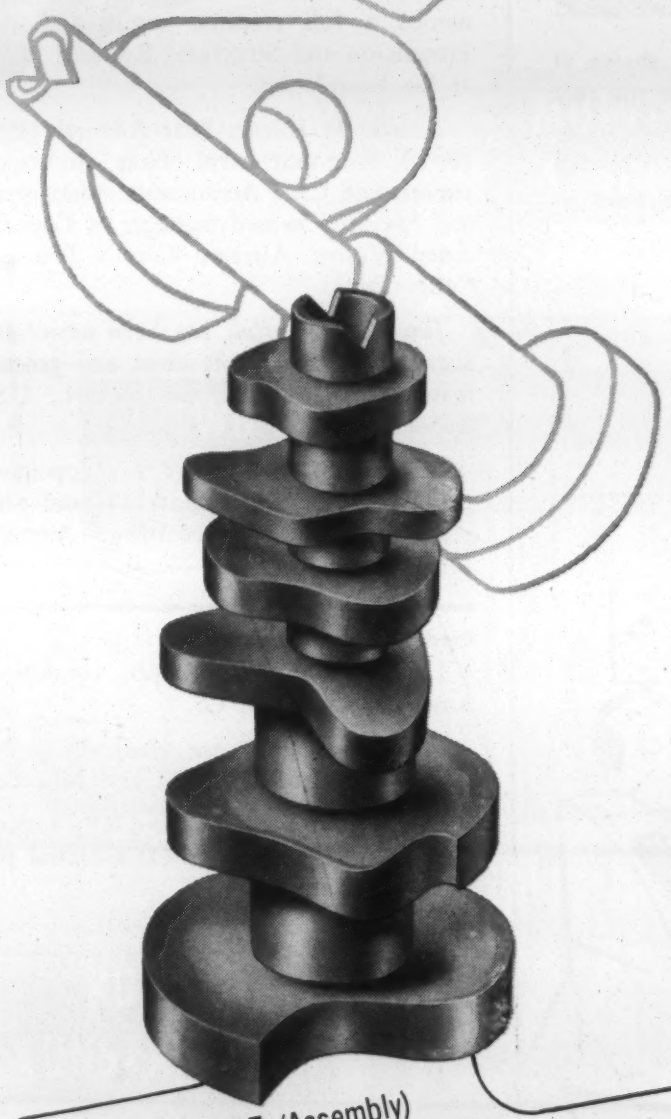
Allen E. Bailey, Jr., a pioneer in industrial electronic control, retired recently

Miracle ... NO!

AN ENGINEERING ACHIEVEMENT

When 7 Parts are Reduced to 1

True it's something of a record when 7 parts are combined to make 1 . . . eliminating all except 1 reaming operation.



PART NO. 90267 (Assembly)
METAL . . . Cold Rolled Steel
PARTS . . . 6 Cams, 1 Shaft
1) Shaft — turned, drilled, faced and slotted from bar stock
2) Cams — profiled, drilled and reamed
ASSEMBLY . . . By brazing
FINISHING . . . Finish grind cam surfaces

REDESIGNED AS CASTING (SINGLE UNIT)
METAL . . . Beryllium Copper
PARTS . . . Single Casting
FINISHING . . . Ream Shaft & Heat Treat
EST. SAVINGS . . . Tools 60%, Finished Part 40%

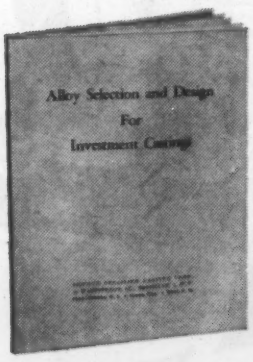
PROOF POSITIVE

The illustrated cam originally required 7 parts, individually machined out of cold rolled steel, and then assembled by brazing.

ARWOOD ENGINEERS

Redesigned the part to incorporate all 7 parts into one casting. What's more the alloy was changed to give improved service and longer life . . . all at substantial savings.

WOULD YOU LIKE TO INVESTIGATE?



Let our engineers show you how to apply the precision casting process in your industry, so your company can also realize substantial savings in money and production time. Drop us a line and we will have one of our sales engineers call on you.

★

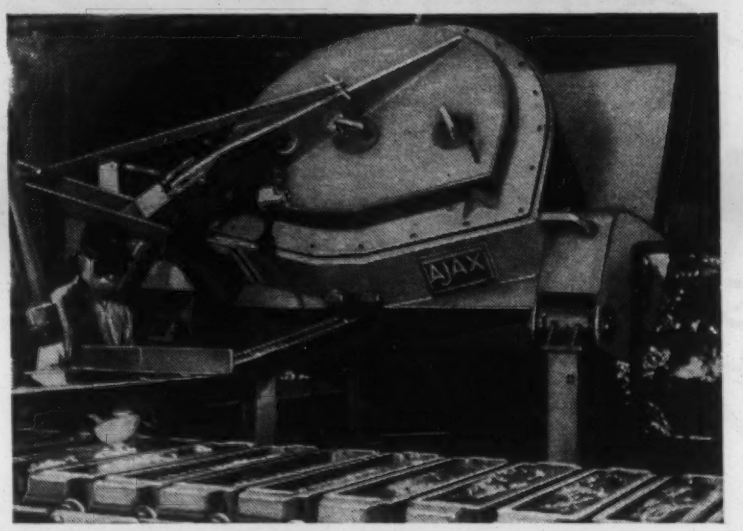
If you would like further information about the process before requesting our representative, write for our booklet, "Alloy Selection and Design for Investment Castings." *We also recommend the book "Investment Castings for Engineers", published by Reinhold Publishing Corp.*

Increase Your Profits... get the highest

possible recovery of aluminum scrap with the help of

AJAX INDUCTION FURNACES

AJAX induction furnaces are used in many plants for the efficient recovery of loose scrap, such as foil, chips, borings, turnings and the like. They are also adaptable for the full range of non-ferrous metals and alloys with the same advantages obtained in aluminum, and are built in sizes ranging from 20 kW to 1400 kW.



AJAX line frequency induction furnaces will melt aluminum foil scrap with the lowest obtainable melting losses. Photo shows an AJAX 166 kW melting furnace installed at the plant of the Toyo Aluminum Works in Yao, near Osaka, Japan. Unbaled foil scrap shown at right edge of photo is remelted at the rate of about 900 pounds per hour with a recovery of over 99%. Molten metal is poured into ingot molds as shown in the front of the photo.

Send for reprint of article on scrap recovery by induction furnaces

AJAX ENGINEERING CORP., TRENTON 7, N. J.

AJAX TAMA-WYATT INDUCTION MELTING FURNACE

AJAX ELECTRO METALLURGICAL CORP., and Associated Companies
AJAX ELECTROTHERMIC CORP., Ajax Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC., The Ajax Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax Wyatt Induction Furnaces for Melting

Tell Us Your WELDING TROUBLES... Perhaps We Can Help You

Pull up a couch and let's talk about those welding problems that you've run into. *CHAMPION* representatives may have the solution to your difficulties. And their advice is given free of charge to "patients" all over the country.

CHAMPION electrodes might be the prescription that answers all your questions. Why not find out?

Phone or contact your *CHAMPION* sales agent or distributor . . . he will be glad to diagnose your case. Make an appointment today.

THE CHAMPION RIVET CO.

CLEVELAND 5, OHIO • EAST CHICAGO, IND.

News Digest

News of Engineers (cont.) . . .

from General Electric Co. after 37 years of service.

John A. Marsh, assistant vice president and manager of Operating Dept., The International Nickel Co., Inc., has been elected vice president of the company.

Robert Reed Denison, former contact metallurgist with the Sheffield Steel Co., has been named a full research metallurgist at Armour Research Foundation, Illinois Institute of Technology, and *Allan Juster,* former project engineer with the National Bureau of Standards, has been named a full research engineer in the Propulsion and Structural Research Dept. at the Foundation.

Charles F. Horne, Rear Admiral, USN (Ret.), long-time naval officer, electronics expert, and Civil Aeronautics Administrator, has been named manager of Consolidated Vultee Aircraft Corp.'s Pomona, Calif. Div.

James C. Westfall has been named assistant to the vice president and general manager, Mechanical Goods Div., U.S. Rubber Co.

William M. Steffen has been appointed general supervisor of materials and process engineering for Northrop Aircraft, Inc.

Died . . . .

Dr. Alphons Otto Jaeger, consultant, American Cyanamid Co.

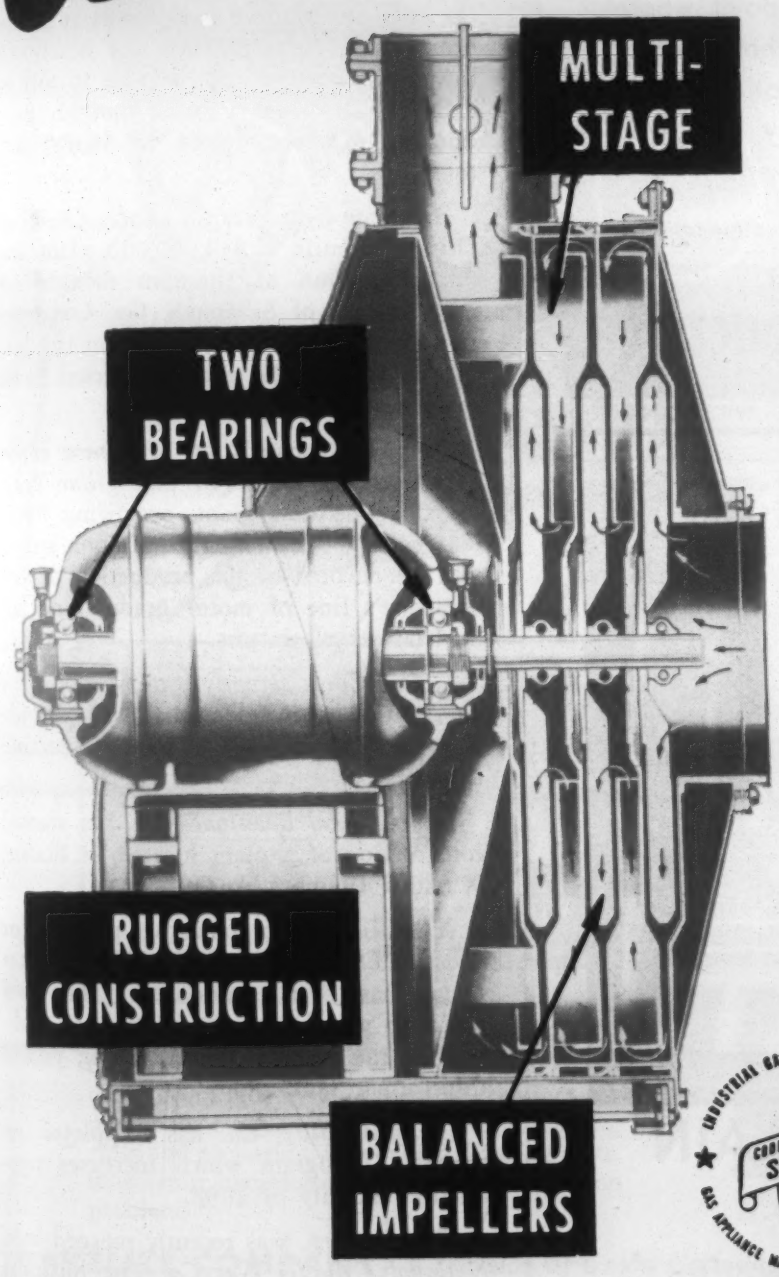
Fred Comstock Boyce, chairman of the board of directors, D. J. Murray Mfg. Co.

Dr. Theodore Whittelsey, Sr., former director of U.S. Rubber Co.'s central research laboratory.

News of Companies

Plans for a $3,500,000 product development laboratory have been announced by the *Large Steam Turbine and Generator Dept., General Electric Co.* The purpurpose of the laboratory is to improve

CONTINUOUS PRODUCTION *Assured 4 Ways* WITH SPENCER TURBO-COMPRESSORS



There are good reasons why the annual installation of Spencer Turbos has increased tenfold in ten years and why a recent analysis shows that repair parts amount to less than one dollar per machine per year.

No. 1. The Spencer multi-stage construction allows a smaller diameter machine with lower peripheral speeds of the fan blades and of the motor itself. The wear on the bearings is therefore cut to a minimum.

No. 2. The only rotating contacts are at the two ball bearings, which if kept greased will assure satisfactory operation without work stoppages for many years.

No. 3. Here is a machine as simple as an electric fan, with a rugged construction, as sturdy as a steel bridge and with wide clearances between the rotating elements and stationary parts. Users say "the Spencer goes on forever with little attention."

No. 4. Balanced Impellers. Each fan is individually balanced before the machine is assembled. This decreases the vibration, increases the life of the bearings and packing and produces quiet performance.

INDUSTRIAL GAS EQUIPMENT DIVISION · CODE OF ETHICS SIGNER · GAS APPLIANCE MANUFACTURERS ASSOCIATION
SIGNER NO. 29

35 TO 20,000 C.F.M.; 4 OZ. TO 10 LBS.; 1/3 TO 1,000 H.P.

440-H

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SPENCER
HARTFORD

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METAL SPINNING
DEEP DRAWING
WELDING — All Types, Including Inert Gas
ASSEMBLING

COSTS dictate methods when economy of production is your objective. The experience and knowledge of PHOENIXSPUN specialists quickly determine the quantity production point where costs of one forming method exceed that of other techniques. The resulting recommendation brings to a focus both quality and economy factors in efficiently handling the project involved.

Submit your prints and "specs" for prompt analysis and quotations.

SEE OUR CATALOG IN SWEET'S
For Product Designers

Metal Spinning Div., PHOENIX PRODUCTS CO.

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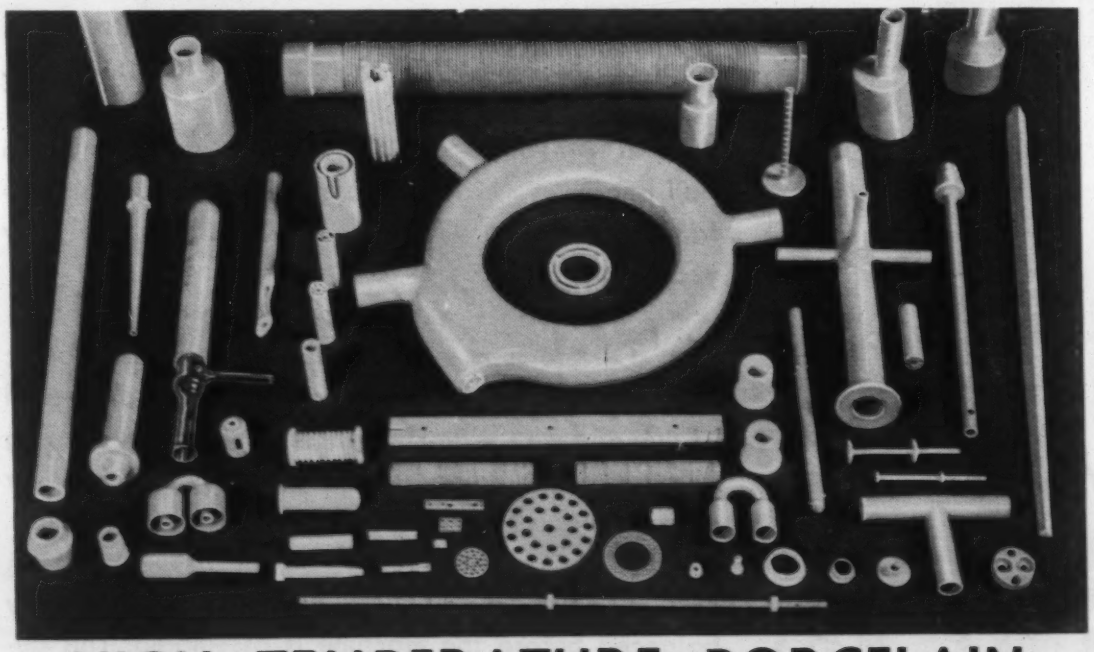


HIGH TEMPERATURE PORCELAIN SPECIALTIES

Many of America's manufacturers, scientists, and research workers depend upon McDanel to supply porcelain parts to meet special requirements. McDanel not only fabricate parts to your specifications, but will develop a body to meet particular applications.

Let us help you solve your problems.

McDANEL Industrial PORCELAINS

McDANEL REFRACTORY PORCELAIN CO.
BEAVER FALLS, PENNA.

GRINDING BALLS . . . MILL LINING BRICK . . .
MILL HEAD ASSEMBLIES . . . TANK & DRYER LININGS

News Digest

News of Companies (cont.) . . .

the design of turbine components for more efficient use of steam in the generation of electricity.

Cornell Iron Works recently celebrated its 125th Anniversary.

Easton Metal Powder Co. has put a new plant into operation for the production of iron powder, using the famous RZ process.

Pittsburgh Steel Co. recently unveiled a new hot mill at Allenport, Penna., an event which formally launched the company into the sheet steel market. At present the mill can produce steel sheets at a rate of about 1,770 ft per min., or nearly 20 mph. Ultimately it will be able to roll at a much faster rate. Current monthly production will be limited to 50,000 net tons.

American Cyanamid Co's Calco Chemical Div. will build a $14,000,000 plant for the production of titanium dioxide on the outskirts of Savannah, Ga. Construction of the new plant will begin the last quarter of this year and is expected to be completed early in 1955.

Plans for construction of a new plant have been announced by *Caterpillar Tractor Co.* The new plant, occupying 700,000 sq ft of manufacturing floor space, will be devoted to the production of the company's line of motor graders and industrial wheel tractors.

Dollin Corp. recently broke ground for an addition to its plant that will provide a 60 to 75% increase in total production capacity.

International Resistance Co. has started construction of a plant located in Boone, Watauga County, N. C.

A million-dollar building project for *General Electric Co.'s Power Transformer Dept.* has been announced. The new building will be an 80 by 210 ft addition to the present 1,000 ft long power transformer tank shop.

Certified Alloys Co. has completed its expansion program which increases production capacity by 40%.

Girdler Corp. was recently merged into *National Cylinder Gas Co.* The business of Girdler will be carried on by National as a division which has been named *The Girdler Co.*, and there will be no change in location or personnel.

Ipsen Industries, Inc. has opened a new sales and service division located at 3400 Tudor St., Philadelphia.

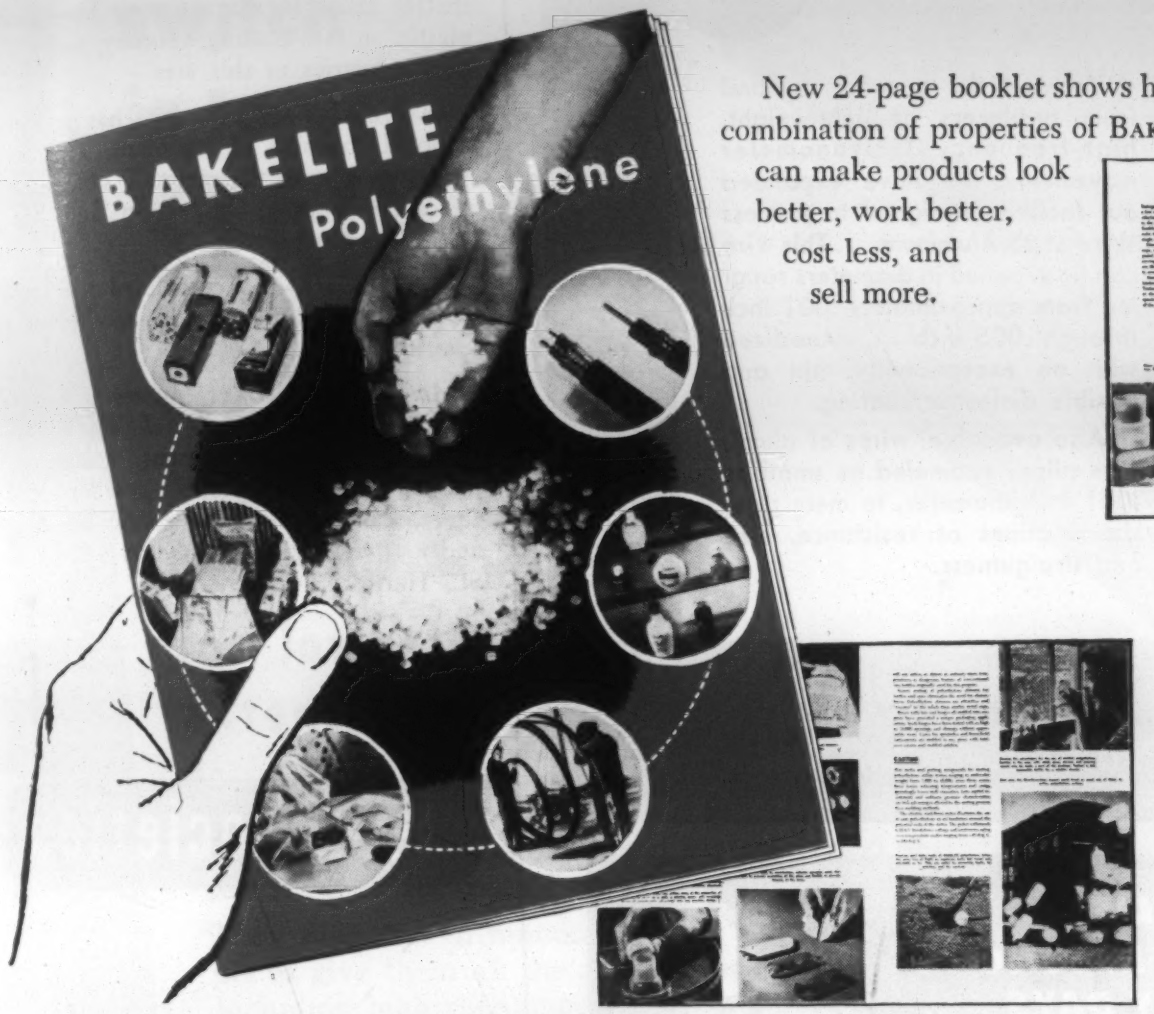
Yale & Towne Mfg. Co. has purchased the business and assets of *Powdered Metal Products Corp. of America.*

Reichhold Chemicals Inc. has an-

This new idea generator packed with facts about

BAKELITE TRADE-MARK Polyethylene

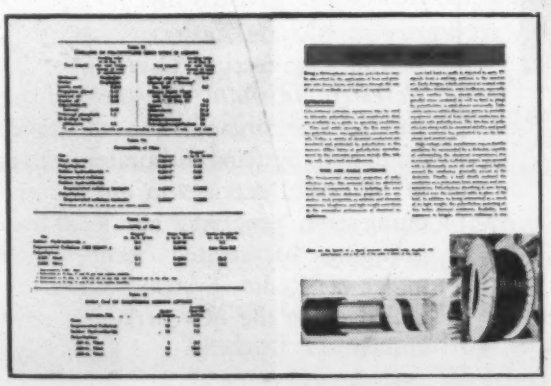
can help turn your ideas into tomorrow's profits



New 24-page booklet shows how the unusual combination of properties of BAKELITE *Polyethylene* can make products look better, work better, cost less, and sell more.

You can see how products benefit by BAKELITE *Polyethylene's* flexibility, light weight, chemical resistance, low water permeability, excellent dielectric properties, impact resistance, formability.

You can learn the many different ways you can fabricate BAKELITE *Polyethylene* . . . how it can be injection or blow-molded; extruded as film, tubing, rod, tape, monofilaments; calendered, cast, or applied to other materials as hot-melts or by flame-spraying.

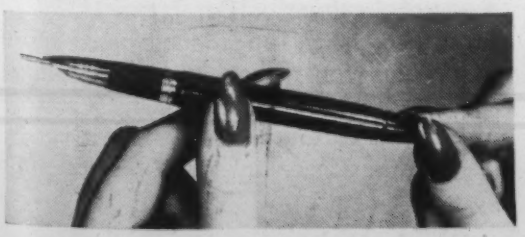


You can visualize how the advantages of BAKELITE *Polyethylene* can be applied to almost every conceivable type of product, in practically every industry . . . in revolutionizing sales and packaging, in reducing shipping costs, in solving materials-handling and installation problems.

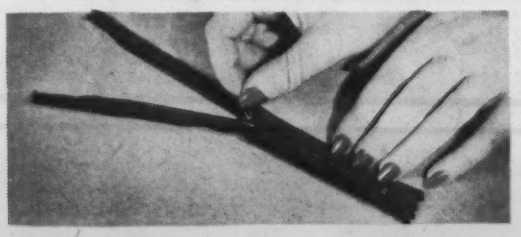
You can plan for a bigger future, now, by investigating what BAKELITE *Polyethylene* can do for your own products, when it becomes more freely available. New plants are under construction to expand production in order to alleviate present short supply. Time your own development work so you will be ready. Start today, by writing for a free copy of this idea-stimulating booklet. Write Dept. QR-17.

BAKELITE TRADE-MARK
Polyethylene

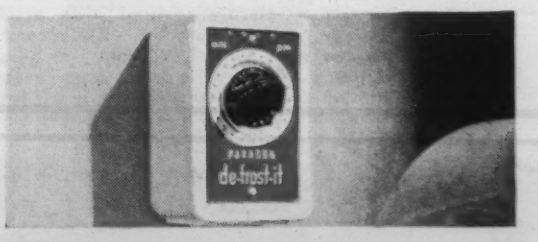
BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.



SHEAFFER SNORKEL pen has cap, barrel, plunger knob, and gripping section molded of BAKELITE C-11 Plastic, providing fine finish, good color, precise fitting, durability. Made by W. A. Sheaffer Pen Company, Fort Madison, Ia.



LASTING COLOR for slide fasteners is achieved with lacquer coatings based on VINYLITE Brand Resins. They withstand usage, cleaning solutions, and boiling soapy water. By Stoner-Mudge, Inc., Pittsburgh 33, Pa. for Crown Fastener Corp.



CONTROL CASE for automatic refrigerator defroster is molded of BAKELITE Phenolic Plastic, permitting simplified fast production. Molded for Paragon Electric Company of Two Rivers, Wisconsin, by Lapcor Plastics, Inc., Manitowoc, Wisconsin.

Fine
ALUMINUM
WIRE

• To meet the growing demand from producers of light-weight, high-frequency Galvanometer movements, we have expanded our facilities designed to process *Wire of 2S Aluminum* . . . This wire can be supplied in diameters ranging from approximately .001 inch through .005 inch . . . *Anodized* with an exceptionally thin and flexible dielectric coating.

Also available: wires of aluminum alloys *enameled* as small as .001 inch diameter, to meet rigid specifications of resistance, size and straightness.

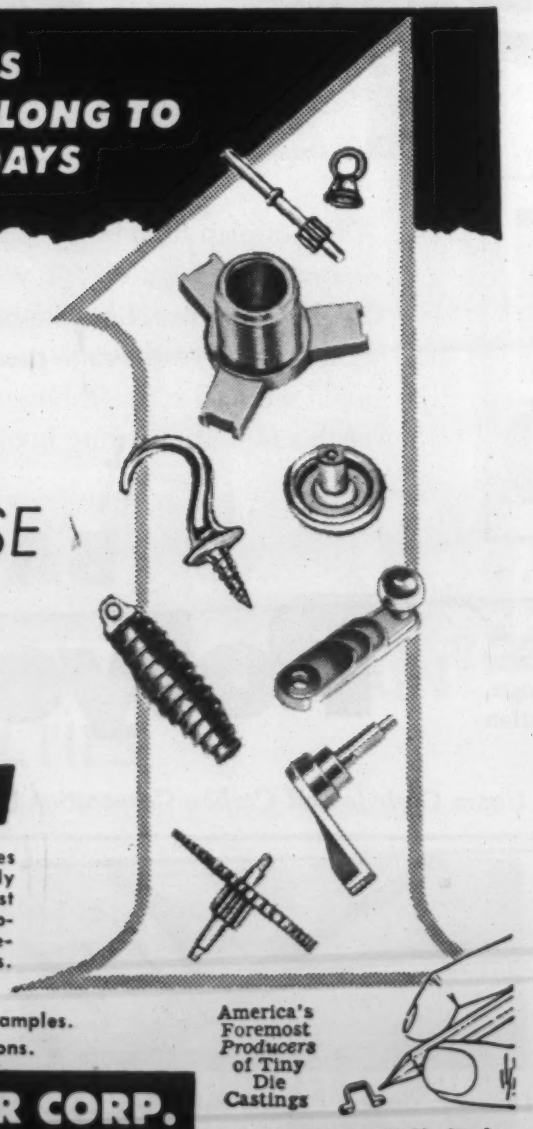
SINCE 1901

Write for Latest List of Products

SIGMUND COHN CORP. 121 So. Columbus Avenue • Mount Vernon, N.Y.

MULTIPLE ASSEMBLIES
FOR SMALL PARTS BELONG TO
HORSE-AND-BUGGY DAYS

GRIES
DIE CASTINGS
GIVE YOU TINY
PARTS LIKE THESE
COMPLETE
IN **ONE**
OPERATION



Compare GRC small die castings with assemblies produced by other methods. GRC completely finished parts save you time, labor, money. Cast in one high-speed operation, they open broad opportunities for your new designs. Fast delivery on 100,000 pieces to many millions.

Write today for bulletin and samples.
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Smallness Unlimited
Max. Wt.: ½ oz.
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News Digest

News of Companies (cont.) . . .

nounced plans for the construction of a new synthetic resins plant in the Fairfax Industrial District of Kansas City. The new plant will be designed to produce special resins for the growing fiber glass plastic, surface coating, foundry, and aviation industries in this area.

Industrial Tectonics, Inc. has recently doubled the size of its plant. The new addition houses the general offices and precision lapping, inspection and engineering departments.

Herlec Corp. has completed the move of all its operations to its new plant at Grafton, Wis.

American Sinterings, a newly formed division of *American Tool Works,* has been created to experiment, design and manufacture in the field of powder metallurgy. The division is headed by Alexander Alves and is located at 132 Allyn St., Hartford, Conn.

News of Societies

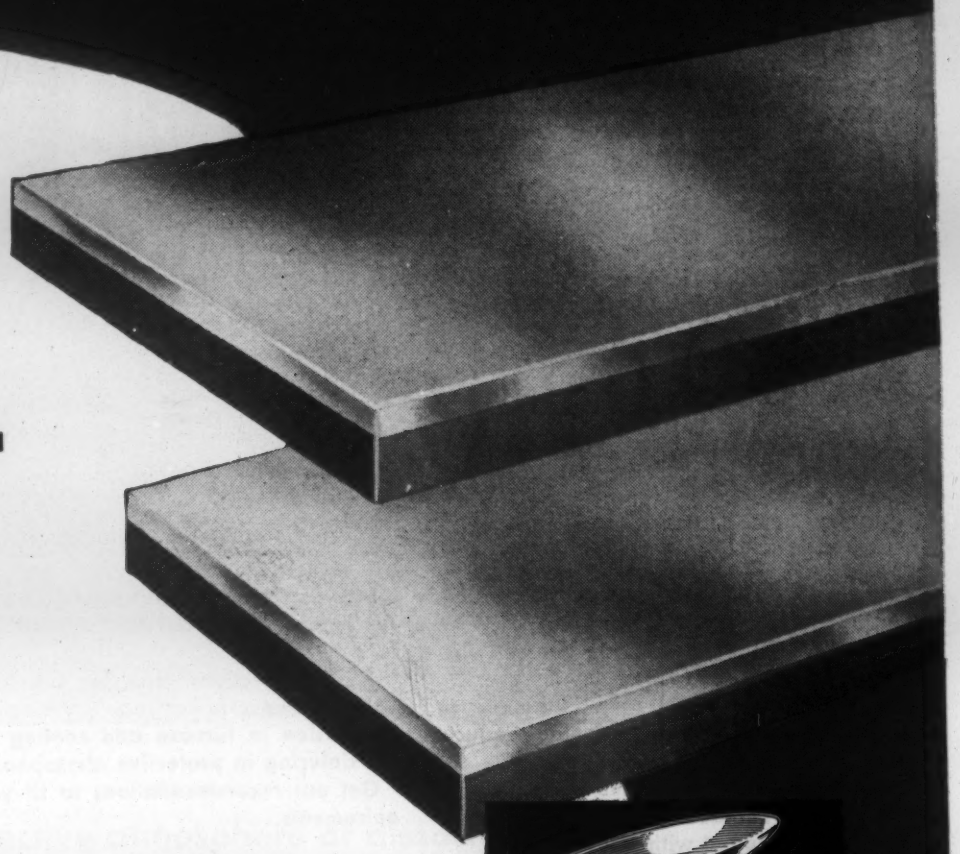
The Engineering Division of *Stanford Research Institute* has revised and expanded the organization of its Aircraft Radiation Systems Laboratory. Expansion of industrial services in aircraft and communication programs has necessitated regrouping of related technical sections under a Radio Systems Laboratory, by which name the new arrangement will be known.

P. J. Underwood has been appointed executive secretary of the *Society of Plastics Engineers, Inc.* Prior to his present appointment, Mr. Underwood was in organizational and public relations work serving as field representative and executive assistant in trade associations in Washington, D. C.

Appointment to the staff of *Southwest Research Institute* of Dr. James H. Wiegand, authority on double-base solid propellants for rockets and guided missiles, has been announced. Dr. Wiegand was named to the post of assistant chairman of the Chemistry and Chemical Engineering Dept.

Dr. T. U. Marron, chemical research supervisor for the A. B. Dick Co. has been named chairman of the *Eighth National Chemical Exposition* by the Chicago Section of the *American Chemical Society*.

the switch is to STAINLESS-CLAD PLATES



for lower costs... extension of material supplies

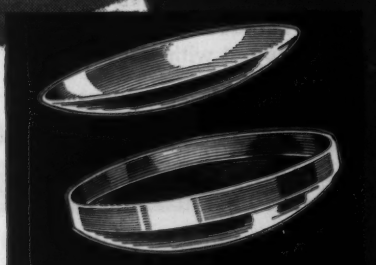
More and more, economy-minded buyers are switching to Stainless-Clad Steel Plates as an effective means of extending supplies of critical materials and of beating the high cost of stainless steel.

They find that in numerous types of fabrication these plates give them all the advantages of stainless steel, including high resistance to corrosion—yet with considerable savings in material costs.

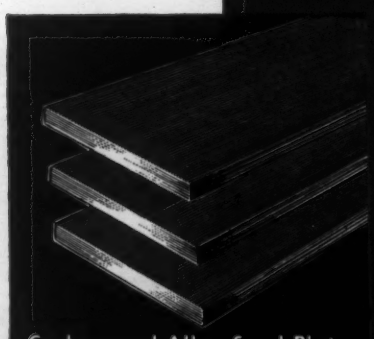
Stainless-Clad Plates made by Claymont are a composite of stainless steel permanently bonded to carbon or alloy steel plate. They're easy to fabricate; will not buckle, crack or peel under the severest forming operations. Stainless cladding may be of any specified percentage of total plate from 10% to 50%.

Other Claymont products include Flanged and Dished Heads, Alloy and Carbon Steel Plates, Large Diameter Welded Steel Pipe.

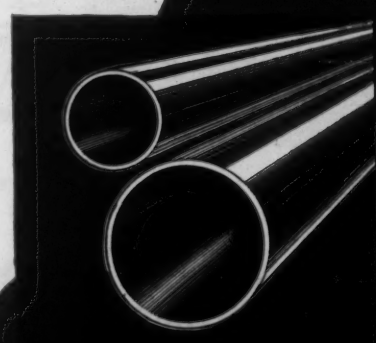
To order, write or call Claymont Steel Products Department, Wickwire Spencer Steel Division, Claymont, Delaware.



Flanged and Dished Heads



Carbon and Alloy Steel Plates



Large diameter steel pipe

THE COLORADO FUEL AND IRON CORPORATION—Denver, Colorado
PACIFIC COAST DIVISION—Oakland, California
WICKWIRE SPENCER STEEL DIVISION—Atlanta • Boston • Buffalo • Chicago • Detroit
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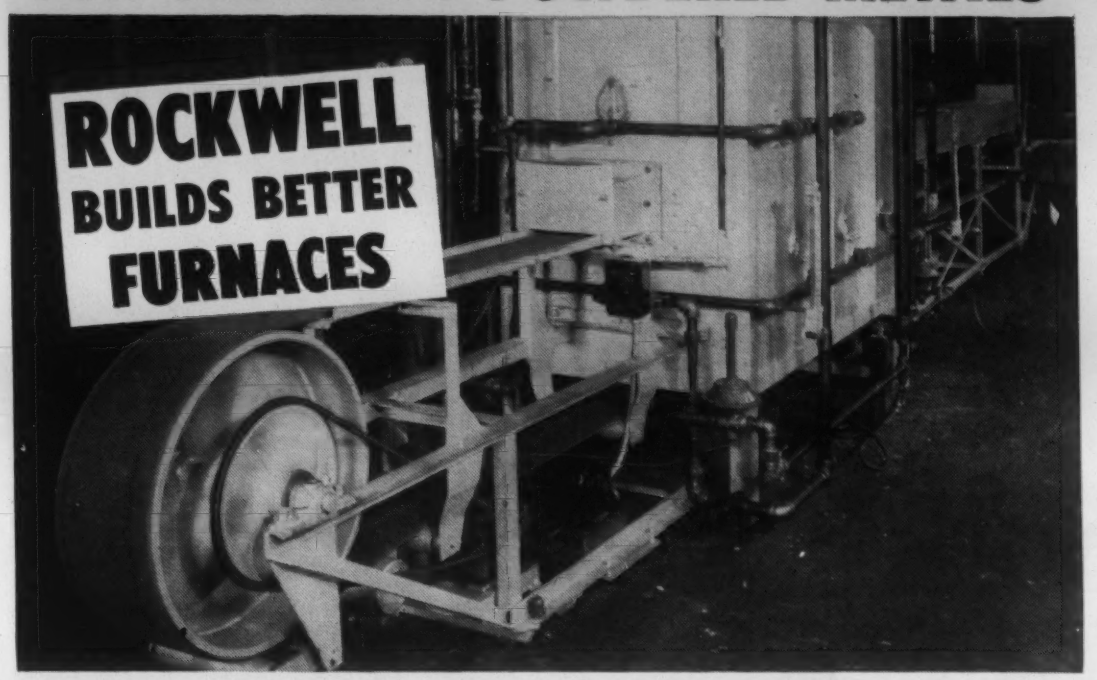
CLAYMONT STEEL PRODUCTS

PRODUCTS OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION

CF&I

FOR SINTERING POWDERED METALS



Continuous Mesh Belt Conveyor Furnaces, with moderate width and length of belt, for medium capacity in sintering pressed ferrous and non-ferrous metal powders.

Continuous Roller Hearth Furnaces for larger capacity of pressed metal products loaded in trays.

Batch Type Furnaces in many sizes.

Fuel-Fired Furnaces for temperatures to 2000° F., equipped with alloy muffle.

Electric Furnaces with resistance elements for temperatures to 1800° F. and Globars to 2400° F.

Cooling Sections may be provided for cooling product to any required temperature.

Provision in furnace and cooling section for sintering in protective atmosphere.

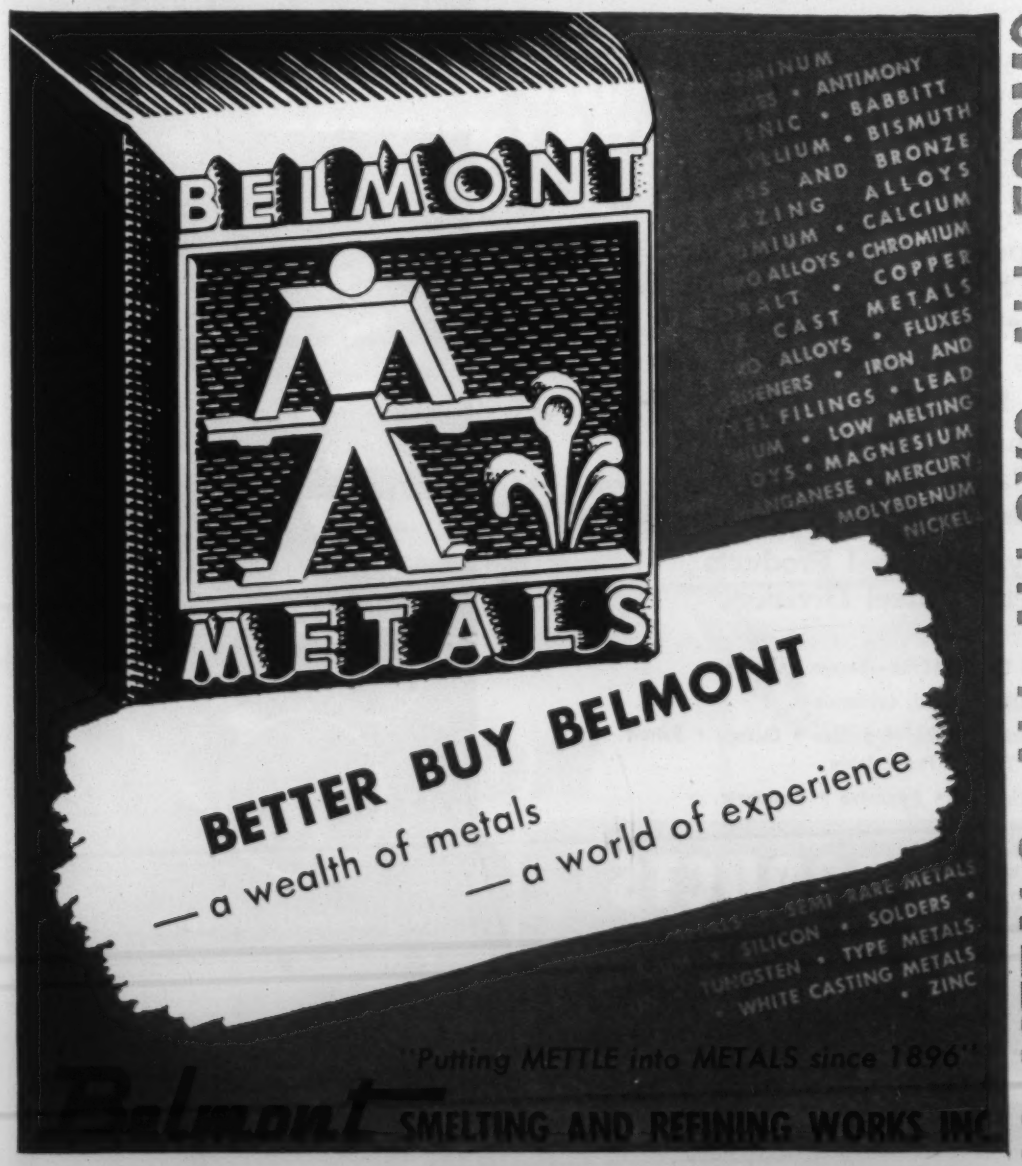
Get our recommendations to fit your requirements.

ROCKWELL SINCE 1888 BUILT

W. S. ROCKWELL COMPANY

FURNACES • OVENS • BURNERS • VALVES • SPECIAL MACHINERY

2083 ELIOT STREET • FAIRFIELD, CONN.



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Meetings and Expositions

ELECTROCHEMICAL SOCIETY, fall meeting. Wrightsville Beach, N. C. Sept. 13-17, 1953.

SOCIETY OF AUTOMOTIVE ENGINEERS, tractor and production forum. Milwaukee. Sept. 14-17, 1953.

PORCELAIN ENAMEL INSTITUTE, annual shop practice forum. Columbus. Sept. 16-18, 1953.

NATIONAL FOUNDRY ASSOCIATION, annual meeting. New York. Sept. 17-18, 1953.

STEEL FOUNDERS' SOCIETY, fall meeting. Hot Springs, Va. Sept. 21-22, 1953.

INSTRUMENT SOCIETY OF AMERICA, national instrument exhibit. Chicago. Sept. 21-25, 1953.

NATIONAL ELECTRONICS CONFERENCE. Chicago. Sept. 28-30, 1953.

SOCIETY OF AUTOMOTIVE ENGINEERS, aeronautic and aircraft engineering display and aircraft production forum. Los Angeles. Sept. 29-Oct. 3, 1953.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Sept. 30-Oct. 2, 1953.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, fall meeting. Rochester, N. Y. Oct. 5-7, 1953.

PRESSED METAL INSTITUTE, annual meeting. Philadelphia. Oct. 7-10, 1953.

GRAY IRON FOUNDERS' SOCIETY, annual meeting. St. Louis. Oct. 8-9, 1953.

SOCIETY OF THE PLASTICS INDUSTRY, INC., New England section meeting. Manchester, Vt. Oct 8-9, 1953.

NATIONAL CONFERENCE ON INDUSTRIAL HYDRAULICS, annual meeting. Chicago. Oct. 8-9, 1953.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Institute of Metals Div., fall meeting. Cleveland. Oct. 19-23, 1953.

AMERICAN SOCIETY FOR METALS, annual meeting. Cleveland. Oct. 19-23, 1953.

AMERICAN WELDING SOCIETY, annual meeting. Cleveland. Oct. 19-21, 1953.

SOCIETY FOR NON-DESTRUCTIVE TESTING, annual meeting. Cleveland. Oct. 19-21, 1953.

NATIONAL METAL CONGRESS & EXPOSITION, Cleveland. Oct. 19-23, 1953.

AMERICAN INSTITUTE OF MINING & METALLURGICAL ENGINEERS, Industrial Minerals Div., fall meeting. El Paso. Oct. 28-31, 1953.

AMERICAN SOCIETY OF BODY ENGINEERS, annual technical convention. Detroit. Oct. 28-30, 1953.

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Technical Reports on Materials

Ferrous

INVESTIGATION OF EFFECTS OF GRAIN SIZE UPON ENGINE LIFE OF CAST AMS 5385 GAS TURBINE BLADES. *C. A. Hoffman and C. A. Gyorgak, July 1953. NACA RM E53D06, 21 pp. Available from National Advisory Commission for Aeronautics, 1724 F St., Washington, D. C.* Longer blade life associated with coarser grain sizes.

CALCULATION OF TENSILE STRENGTH AND YIELD POINT OF NORMALIZED AND ANNEALED STEELS FROM THE CHEMICAL COMPOSITION. *P. D. Gorsuch and D. L. Newhouse, U. S. Naval Research Laboratory, Sept. 1945. PB 109456, 90 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $3.75, photostat $11.25.* A set of multiplying factors for calculating tensile strength and yield point. Cooling curves of plates and rounds. Calculation method for finding tensile strength and yield point for any position in a normalized steel section.

FACTORS FOR THE CALCULATION OF HARDENABILITY. *S. Siegel and J. G. Brooks, U. S. Naval Research Laboratory, Sept. 1945. PB 109279, 95 pp. Available from Library of Congress, Publication Board Project, Wash. 25. D. C. Microfilm, $4.25, photostat $12.50.* Factor curves for carbon and manganese in steel alloys differing radically from those presented by previous investigators in the field of hardenability.

HARDENABILITY OF CAST STEEL. *K. L. Clark and J. H. Richards, Naval Research Laboratory, June, 1944. PB 109459, 37 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm, $2.25, photostat $5.00.* Consideration of grain size in hardenability of identical compositions of cast and forged steel. New curve correlating Jominy distance with Grossmann's index of hardenability. New molybdenum curve from reconsideration of Grossmann's data.

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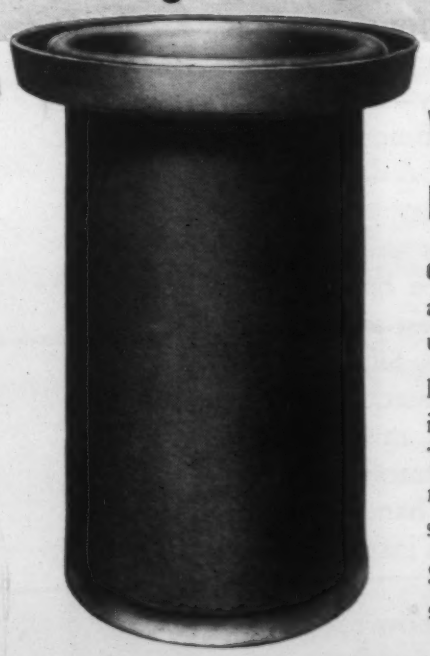

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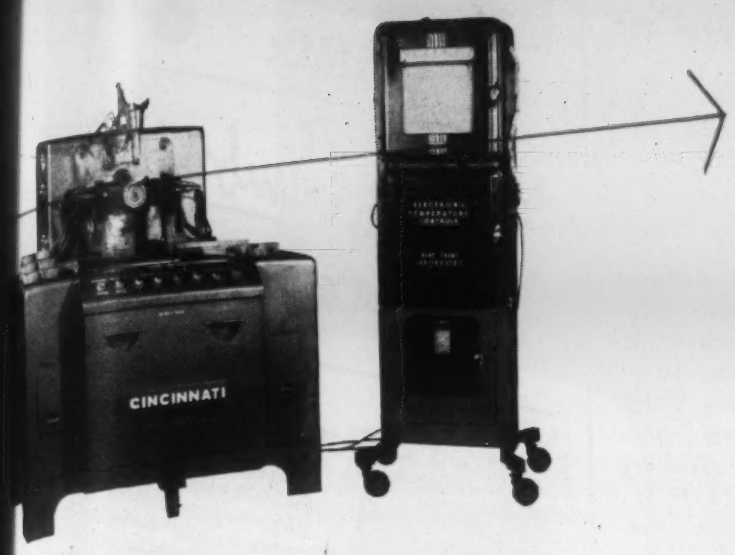

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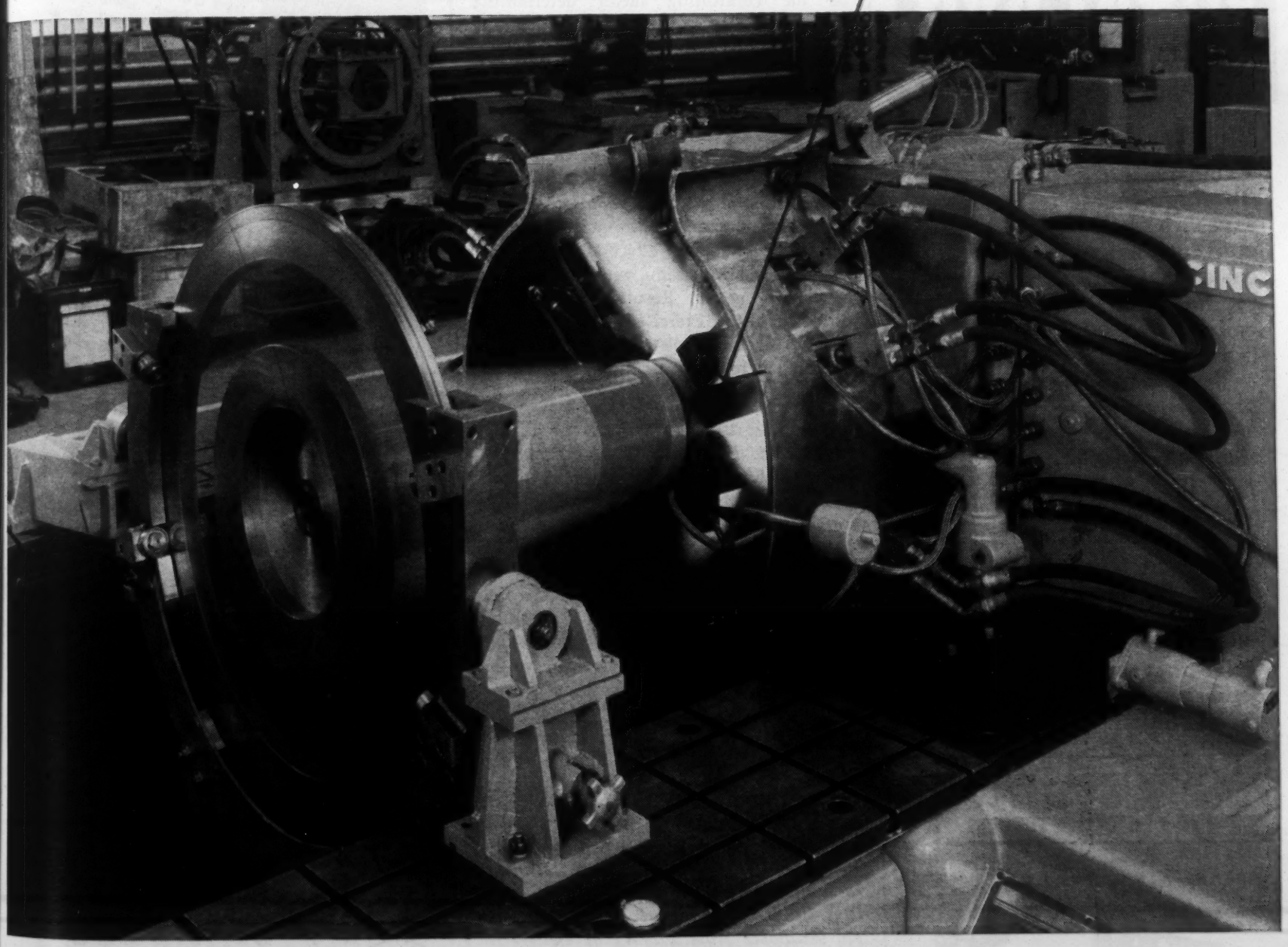

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Technical Reports . . .

continued from page 230

Nonferrous

EFFECT OF PRESTRAINING ON RECRYSTALIZATION TEMPERATURES AND MECHANICAL PROPERTIES OF COMMERCIAL SINTERED, WROUGHT MOLYBDENUM. *K. C. Dike and R. A. Long, July, 1953. NACA TN 2973, 25 pp, diagrams, photos. Available from National Advisory Committee for Aeronautics, 1724 F St., Wash. 25, D. C.* Molybdenum prestrained to 35% or less maintained one hour recrystallization temperature over 2900 F. When stress relieved, metal so fabricated maintained at room temperature equal ductility and ultimate tensile strength within 10% of metal swaged 99%. Equivalent strength and ductility was obtained at 1800 F over the range 10-99% swaged. Swaging found to effect recrystallized grain size, but not to be the controlling factor determining ductility of recrystallized molybdenum.

COMPARATIVE STUDIES OF THE ELECTRICAL CONTACT PROPERTIES OF TITANIUM. *S. Jurich, Wright Aeronautical Development Center, Feb. 1952, 76 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $3.50, photostat $10.00.* Titanium compared to copper, aluminum and steel. Relative effect of heat and moisture on titanium when used with dissimilar metals. Results indicate that care should be exercised in selection of metal combinations used to electrically connect wires to titanium panels or chassis.

MECHANISM OF PASTIC FLOW IN TITANIUM. *C. A. Dube and B. H. Alexander, Sylvania Electric Products Inc., Metallurgical Laboratories. First Quarterly Progress Report, Nov. 1950 to Jan. 1951, 4 pp. Report 109153. Microfilm $1.25, photostat $1.25. C. A. Dube, F. Perkins and B. H. Alexander. Second Quarterly Progress Report, Feb. to May, 1951, 13 pp. Report 109154. Microfilm $1.75, photostat $2.50. Available from Library of Congress, Publication Board Project, Wash. 25, D. C.* Slip and twinning planes of titanium determined, recrystallization studies, preliminary study of secondary recrystallization, apparatus for study of stress relaxation.

OXIDATION OF BERYLLIUM AT HIGH TEMPERATURE. *D. Cubicciotti, Illinois Institute of Technology, Dept. of Chemistry, July, 1949. Report PB 108748, 16 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.75, photostat $2.50.*

Parts and Forms

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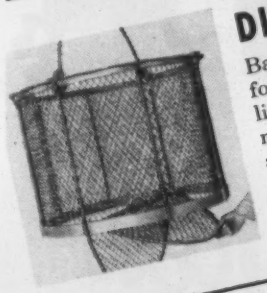

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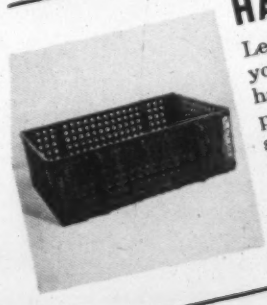

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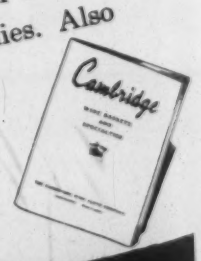

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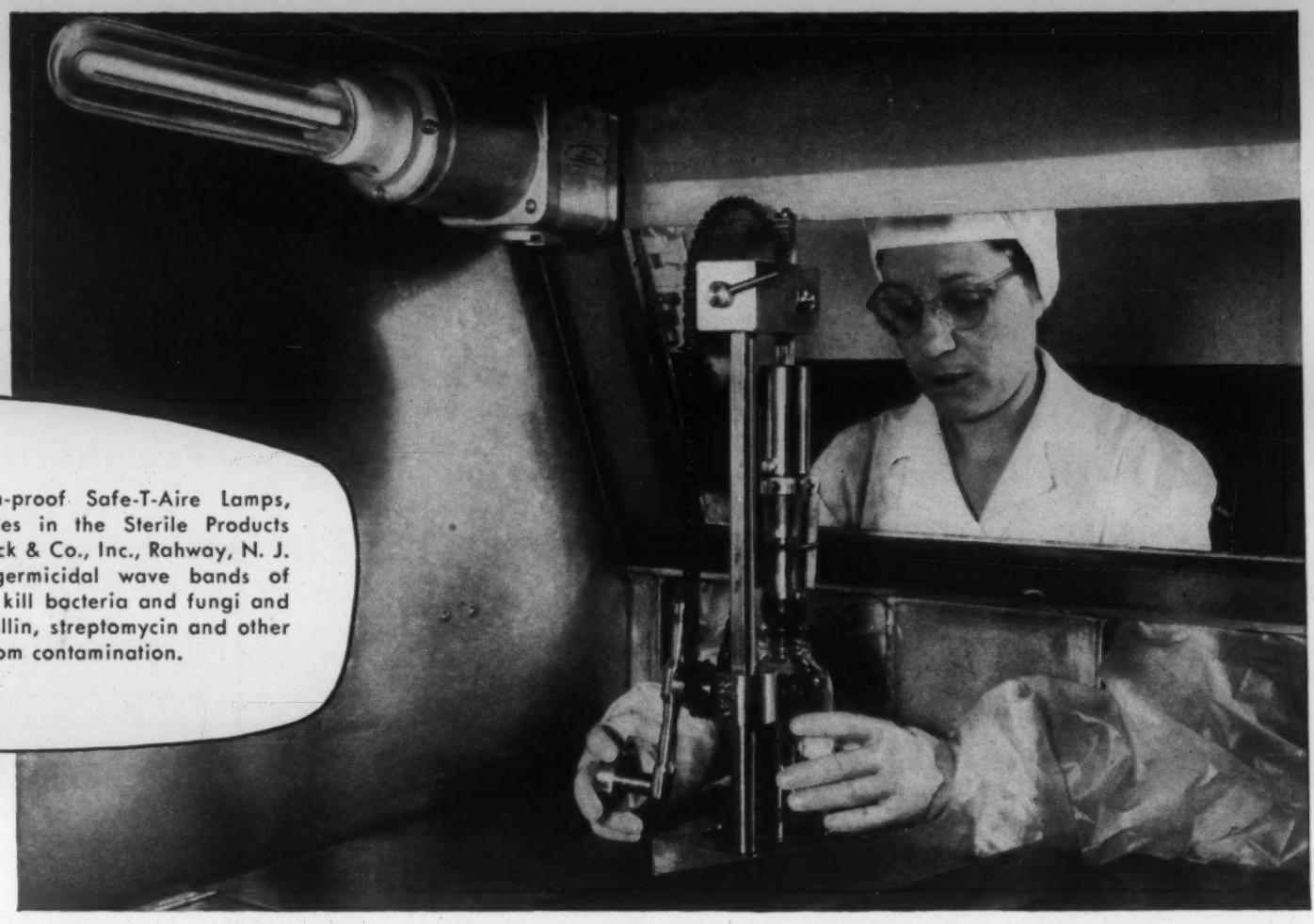

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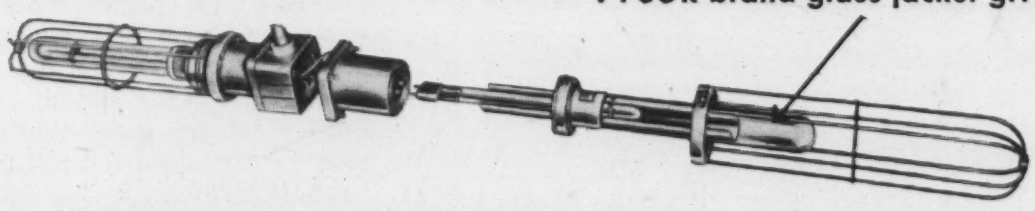

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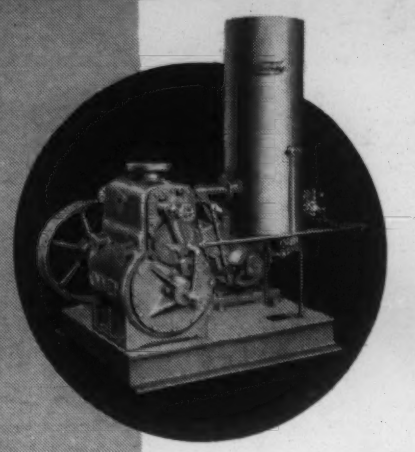

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Technical Reports . . .

continued from page 232

WEB DEPTH TO WEB THICKNESS OF APPROXIMATELY 60. *L. Ross Levin, Langly Aeronautical Laboratory, May, 1953. NACA TN 2930, 11 pp. Available from the National Advisory Committee for Aeronautics, Wash. 25, D. C.* Strength of plane diagonal-tension webs. Portal frame effect.

EFFECT OF VARIATION IN RIVET STRENGTH ON THE AVERAGE STRESS AT MAXIMUM LOAD FOR ALUMINUM ALLOY, FLAT, Z-STIFFENED COMPRESSION PANELS THAT FAIL BY LOCAL BUCKLING. *Dow, Hickman and Rosen, June, 1953. NACA TN 2963, 17 pp. Available from the National Advisory Committee for Aeronautics, Wash., D. C.*

FABRICATION OF DIES FOR PRINTED CIRCUITS. *R. Brookes, Telecommunications Research Establishment, Great Britain Ministry of Supply, Sept. 1950, 10 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.25, photostat $1.25.*

Joining

RESEARCH ON THE WELDABILITY OF IRON ALLOYS: BEAD-WELD NICK-BEND TEST FOR WELDABILITY. *G. C. Luther, U. S. Naval Research Laboratory, Sept. 1944. Report PB 109292, 46 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.50, photostat $8.50.*

RESEARCH ON THE WELDABILITY OF IRON ALLOYS: EFFECT OF ELECTRODE DIAMETER OF T-BEND RESULTS. *G. C. Luther, U. S. Naval Research Laboratory, June, 1944. Report PB 109286, 31 pp. Available from the Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.25, photostat $5.00.*

SOME OBSERVATIONS ON UNDERBEAD CRACKING IN WELDING OF HIGH-TENSILE LOW-ALLOY STEELS. *J. A. Rinebolt and J. O. Mack, U. S. Naval Research Laboratory, Mar. 1949. Report NRL M 3390, 31 pp. Available from Office of Technical Services, U. S. Dept. of Commerce, Wash. 25, D. C. $1.00.*

CONTROLLED WELDING OF MEDIUM ALLOY STEELS, FIRST PARTIAL REPORT. *C. E. Jackson, U. S. Naval Research Laboratory, August, 1943. PB 109321, 14 pp. Available from the Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.75, photostat $2.50.* Test method permitting the proper choice of pre-heat and post-heat temperatures to set up shorter welding schedules and insure optimum ductility.

BRAZING ALLOYS FOR USE IN HOLLOW STEEL PROPELLER BLADES. *L. R. Jackson and J. B. Holding, Battelle Memorial Institute, Jan. 1944. PB 109420,*

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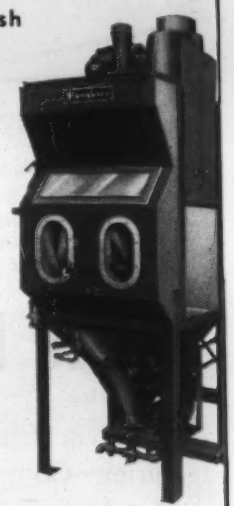

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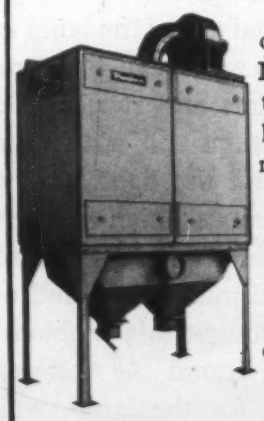

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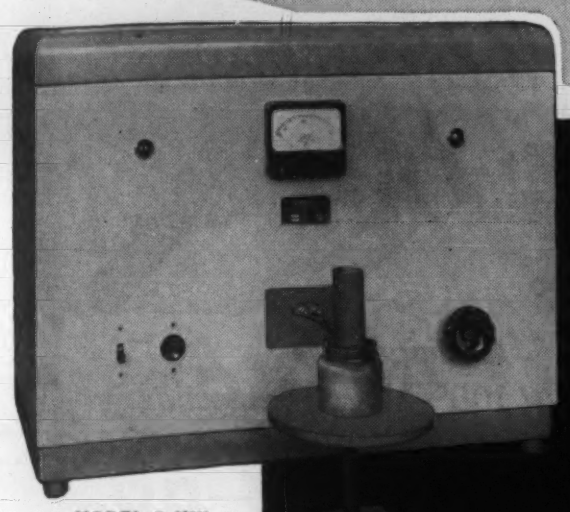

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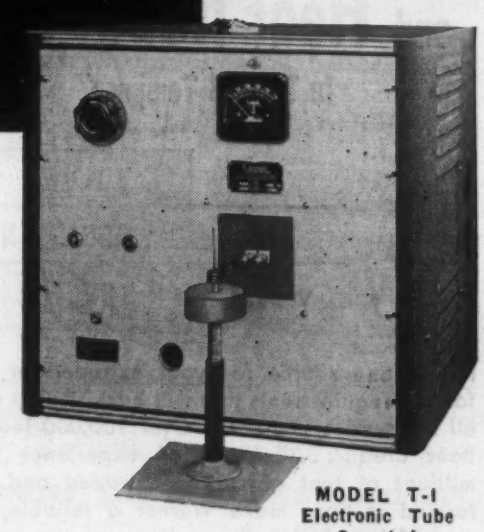

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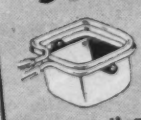

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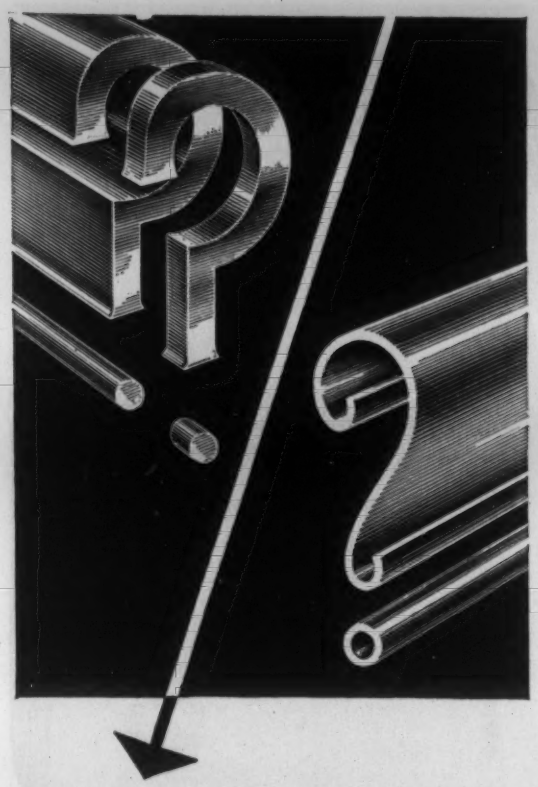
77 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $3.50, photostat $10.00. Joints to withstand more than 50,000 psi stress in outer fibers of the steel for 10,000,000 cycles in fatigu· machine can be brazed. Furnace brazing methods, liquidus temperatures.

STUDY OF SAG RESISTANCE OF HOT PLASTIC ANTI-FOULING PAINT. *S. B. Crecelius and D. Moesta, U. S. Naval Research Laboratory, July, 1945. PB 109338, 22 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $2.00, photostat $2.50.*

General

PRELIMINARY INVESTIGATIONS OF STRENGTH CHARACTERISTICS OF STRUCTURAL ELEMENTS AT ELEVATED TEMPERATURES. *Eldon E. Mathouser and Charles Libove, June, 1953. NACA RM L53E04a, 12 pp. Available from National Advisory Committee for Aeronautics, Wash., D. C.* Methods for predicting structural strength of columns, plates and stiffened panels at uniform high temperatures.

COMPARISON OF LEAD ACID AND ALKALINE BATTERIES FOR USE IN M.T. VEHICLES. *J. W. T. Durrell and S. Pomeroy, Great Britain Royal Aircraft Establishment, Farnborough, England, Feb. 1951. PB 109304, 15 pp. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $1.75, photostat $2.50.*



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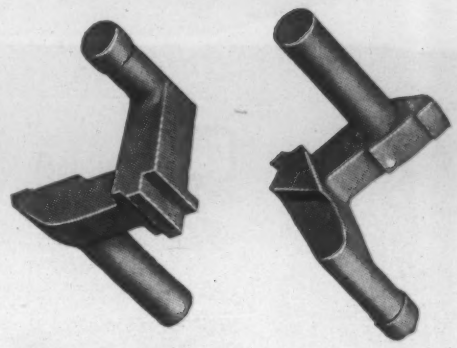

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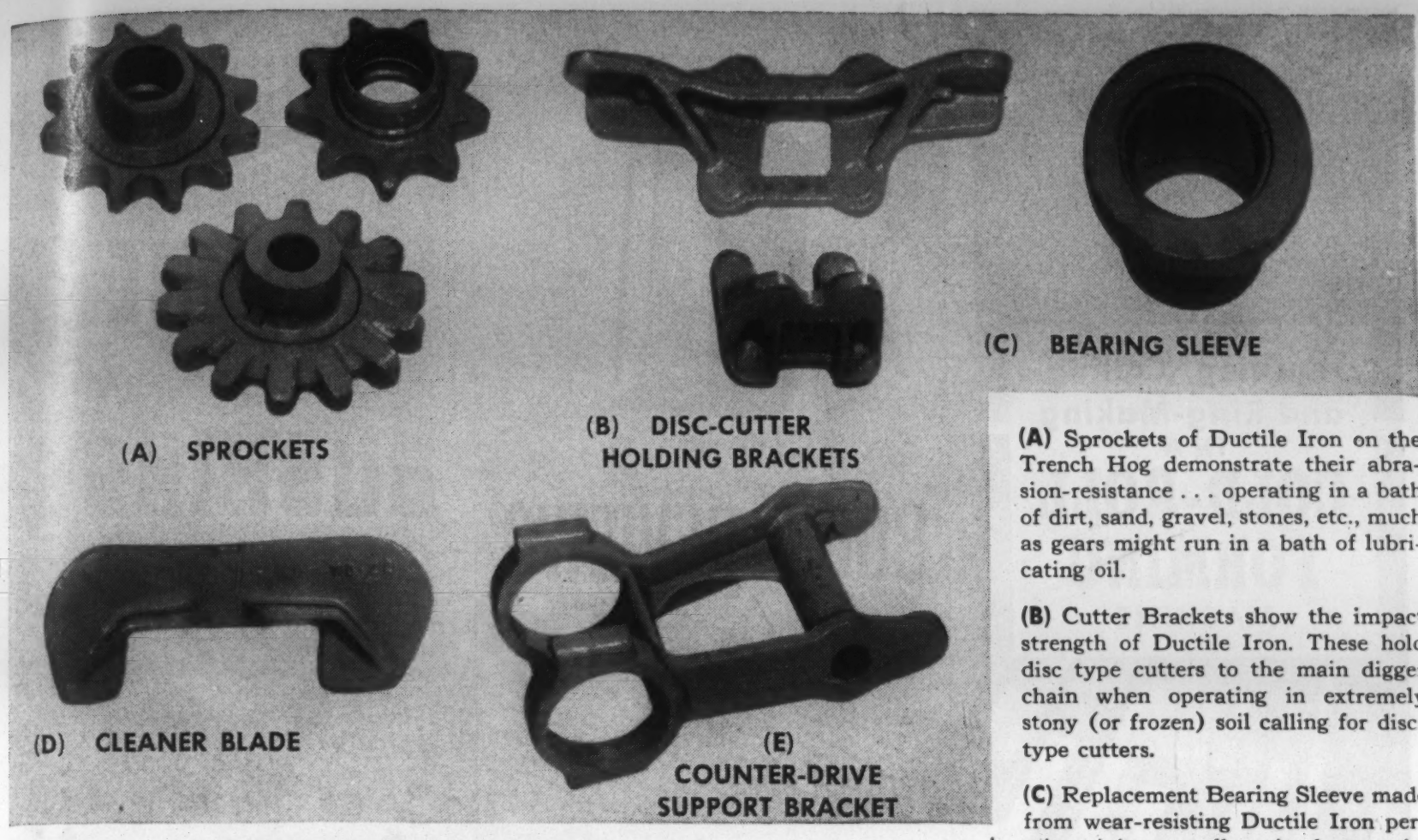

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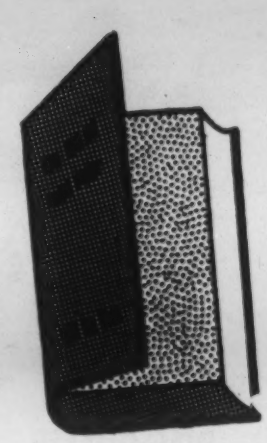

BOOK REVIEWS

Parts and Forms

FABRICATED MATERIALS AND PARTS. *By T. C. Du Mond. Published by Reinhold Publishing Corp., New York 36, N. Y., 1953. Cloth 6 by 9 in. 332 pp. Price $6.50.*

Written especially for the man who knows what his product must do, this book coordinates the information which requires consideration in selecting the method of production most suited for a particular application. Although all the details of design and manufacture are not discussed, information is presented to enable the reader to eliminate unsuitable methods and to indicate those which merit further investigation.

Twenty major methods of producing small industrial parts are discussed. They include casting, forging, cold working by various methods, joining of metallic materials, and methods of forming plastics and other nonmetallics. Fully discussed are costs, suitable materials, advantages and limitations of the process, design factors, size ranges and tolerances which can be met. In an inserted table, eighteen selection criteria are discussed briefly for each of the twenty processes.

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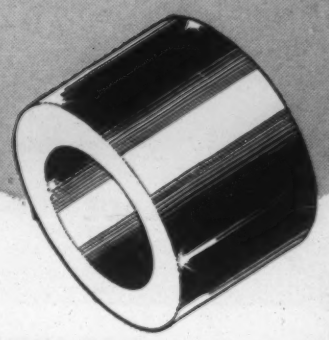

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Book Reviews

(continued)

tive, it offers usable working information on processes which must be considered in every industrial organization.

Powder Metallurgy

PLANSEE PROCEEDINGS 1952. *Edited by F. Benesovsky. Available from The American Electro Metal Corp., Yonkers, N. Y. Cloth, 6 by 9 in. 316 pp. Price $8.00.*

This volume contains the papers on powder metallurgy presented at the first Plansee seminar "De Re Metallica", June, 1952. It contains 29 papers, published in the language in which they were presented, and is divided into three sections.

The first section contains ten papers on general and physical metallurgy and the physics of solids. Subjects included are vacuum melting, fusion and solidification, a new indentation hardness testing procedure, theories of bonding in intermetallic phases and diffusion in solid metals. Nine of the papers are in German, one is in French.

The second section contains twelve papers on powder metallurgy in general. Subjects covered here include powder production, mechanism of sintering, development of alloy powders and effects of oxide films on the properties of compacts. Seven of these papers are in German and five are in English.

In the third section there are seven papers on cemented carbides and other hard metals. Subjects covered are: properties of tungsten carbide - titanium carbide - cobalt hard metals; solid solubilities of some carbides in cobalt, iron and nickel; siliconizing of tungsten and molybdenum; metallography of the hard carbides, borides, silicides and nitrides. Five of the papers are in German, two are in English.

Brief English summaries of the foreign language papers are also included.

(Continued on page 242)

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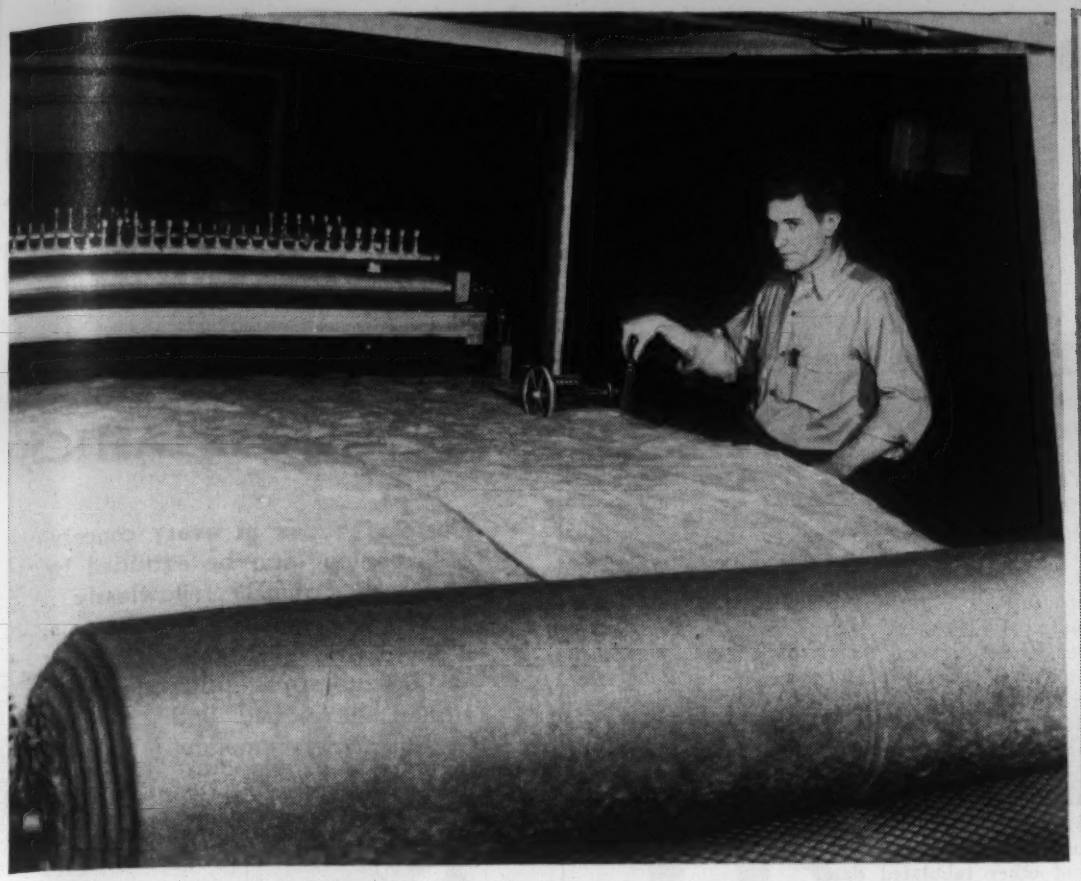

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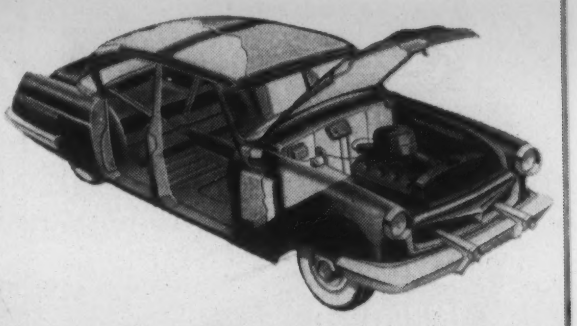

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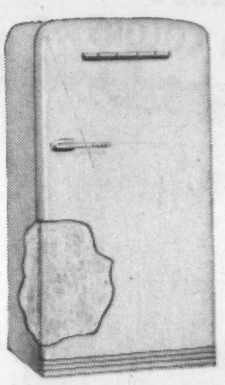

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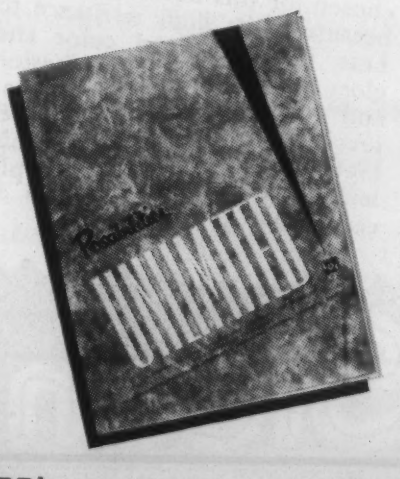

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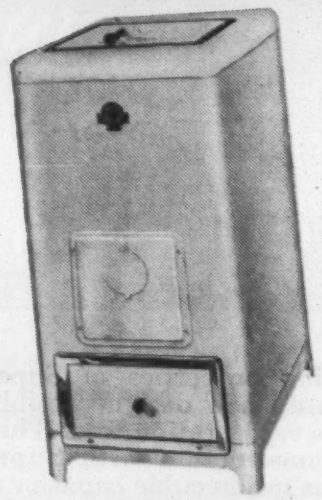

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Book Reviews

(continued)

Other New Books

FERROUS ANALYSIS. *By E. C. Pigott. Published by John Wiley & Sons, Inc., New York, N. Y., 1953. Cloth, 6 by 9 in. 690 pp. Price $12.50.* The second edition of this book is designed to be suitable as a work of reference both for the practicing analyst and the advanced student, as well as for assistants of Inter-B-Sc. standard who may possess more manipulative skill than analytical experience. Covered thoroughly here are such topics as: Analytical Techniques; The Constituents of Iron and Steel (physical properties, extraction, ferrous properties, chemical properties, detection, etc.); Microchemical Analysis of Iron and Steel; Alloys and Ores; Refractory Materials. Tables of Elements, Symbols, Atomic Numbers, Atomic Weights and Isotopes are included along with charts, and other tabulated data.

FORMALDEHYDE *Second Edition. ACS Monograph #120. By J. Frederic Walker. Published by Reinhold Publishing Corp., New York 36, N. Y., 1953. Cloth, 6 by 9 in. Price $12.00.* This new edition offers a modern, systematic summary of the manufacture, properties, chemical reactions and uses of formaldehyde. Special attention is devoted to such important aspects as physical and thermodynamic properties, methods of production, handling characteristics, the analysis of commercial formaldehyde solutions and polymers, the formation of hexamethylenetetramine, and all the latest industrial applications.

METAL INDUSTRY HANDBOOK & DIRECTORY 1953. *Published by Louis Cassier Co., Ltd., London, England, 1953. Paper, 6 by 9 in. 456 pp. Price—Available only with the weekly journal Metal Industry at a combined subscription of $7.45.* Here is a comprehensive reference book for all those concerned with the nonferrous metal industries. Containing up-to-date information on the properties of the newer, as well as the more familiar, metals; an extensive section devoted to summaries of British Standard, Aircraft Material and D.T.D. specifications, it also includes a section on the chief metal finishing processes and data regarding all the common rod, bar, sheet and strip products.

ASTM STANDARDS ON COPPER AND COPPER ALLOYS. *Published by The American Society for Testing Materials, Philadelphia 3, Penna., 1953. Paper, 6 by 9 in. 556 pp. Price $5.00.* This book brings together in convenient up-to-date form all of the ASTM Standards pertaining to copper and copper alloys, which were developed by Committee B-5 on Copper and Copper Alloys, Cast and Wrought, and other ASTM technical committees. The 1953 edition includes 115 widely used ASTM standards, including 102 specifications; 9 test methods; 2 recommended practices—one for tension test specimens for copper-base alloys for sand castings, the other for designating significant places in specified limiting values; and 2 classifications—one for cast copper-base alloys, the other for copper. An extensive index is included to provide a ready reference.

MEASUREMENT TECHNIQUES IN MECHANICAL ENGINEERING. *By R. J. Sweeney. Published by John Wiley & Sons, Inc., New York 16, N. Y., 1953. Cloth, 6 by 9 in. 309 pp. Price $5.50.* The purpose of this book is to provide a source of information in the measurement techniques which are commonly used in performance testing of power equipment, engines,

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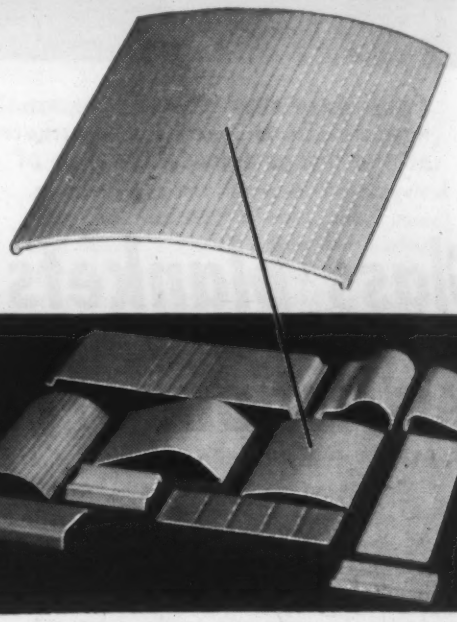

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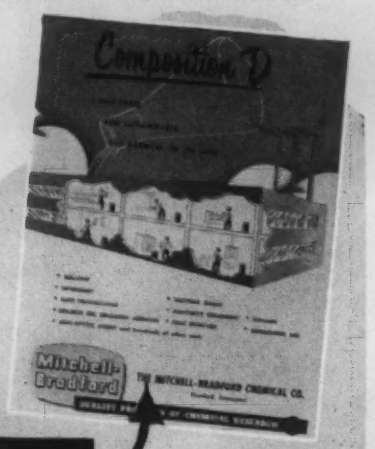

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THE FURANS. *ACS Monograph #119. By A. P. Dunlop and F. N. Peters. Published by Reinhold Publishing Corp., New York 36, N. Y., 1953. Cloth, 6 by 9 in. 867 pp. Price $18.00.* This new monograph offers the first complete treatment on the subject of furan chemistry. It offers the reader a ready source of information on the behavior and applications of all furan types including industrially important furfural. The book is divided into two sections, the first dealing with the chemistry of furan compounds, and the second devoted to industrial applications of furfural and its derivatives.

BIBLIOGRAPHY OF RESISTANCE WELDING. *Bulletin Number 17. Published by Resistance Welder Manufacturers Association, Philadelphia 3, Penna.. 1953. Paper, 8½ by 11 in. Price $1.25.* This bulletin is designed to present as nearly as possible a complete and accurate record of published articles on all phases of resistance welding within the past few years.

PROGRESS IN METAL PHYSICS. *Vol. 4. Edited by Bruce Chalmers. Published by Interscience Publishers Inc., New York, N. Y., 1953. Cloth, 6 by 9 in. 403 pp. Price $9.00.* Presented here are authoritative reviews of the present state of knowledge in specialized aspects of the field that includes both physical metallurgy and metal physics. Subjects covered include: Internal Friction in Metals; The Mechanism of Oxidation of Metals and Alloys at High Temperatures; Gases In Meta's; The Theory of Sintering; Theory of Dislocations; Diffusion in Metals; Nucleation.

THE INERT-GAS-SHIELDED METAL-ARC WELDING PROCESS. *By W. H. Wooding. Published by American Welding Society, New York 18, N. Y., 1953. Paper, 8 by 11 in., 30 pp. Price $1.00.* This pamphlet covers the Educational Lectures on the fundamentals of the inert-gas shielded-metal-arc welding process which were presented at the Annual Meeting of the American Welding Society. There is a brief introduction to arc welding and the developments since World War I, concerning the protection of the arc and molten metal from atmosphere contamination. Particular emphasis is given to welding in inert-gas atmospheres leading to the development of the Inert-Gas-Shielded Metal-Arc Welding Process. With the aid of sketches and photographs, the author portrays the development of the process, the equipment required, the necessary controls and their function.

RECOMMENDED PRACTICES FOR SPOT WELDING ALUMINUM AND ALUMINUM ALLOYS. *Published by American Welding Society, New York 18, N. Y., 1953. Paper, 6 by 9 in. 33 pp. Price $1.00.* This standard is a manual of practical design and manufacturing data. Included is a table showing the combinations of aluminum alloys which can and cannot be spot welded. Mechanical cleaning and specific chemical cleaning methods are given for removal of surface oxide and foreign matter prior to welding. Complete welding schedules are given for frequency converter machines; rectifier machines; electromagnetic and electrostatic stored-energy machines; and standard a.c. machines. A complete chapter is included on weld defects, illustrated by photographs.

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Aluminum Castings Alloy. Acme Aluminum Alloys Inc., 8 pp, ill. Technical data on Acme Almag 35, a light weight aluminum casting alloy combining high strength, ductility and impact resistance. (57)

Aluminum Casting Process. Al-Fin Div., Fairchild Engine & Airplane Corp., 4 pp, ill. Brief articles describing the Al-Fin Process of molecular bonding of aluminum and its alloys to steel, cast iron, nickel or titanium. (58)

Aluminum and Its Alloys. Aluminum Co. of America, 8 pp, ill, No. AD-278. Discusses the use of Alcoa aluminum in the process industries; includes technical data. (59)

Engineering Bronzes. American Crucible Products Co., 12 pp. ill. Includes complete data on facilities, technical information, case histories and applications of Promet bronzes. (60)

Continuous-Cast Copper Alloys. American Smelting and Refining Co., 12 pp. Technical data on company's continuous-cast copper alloy rods, tubes and shapes. (61)

Aluminum Bronze Alloys. Ampco Metal Inc., 20 pp, ill, No. PI-3. Detailed data on corrosion resistance and properties of various aluminum bronze alloys for corrosive applications. (62)

Precision Investment Castings. Arwood Precision Casting Corp., 16 pp, ill. Informative article on precision investment castings. Includes table of ferrous and nonferrous alloys recommended as most adaptable for this process. (63)

Precision Castings. Atlantic Castings & Engineering Corp., 12 pp. ill. "High Quality Precision Castings for Industry" illustrates Atlantalloy casting process, gives specifications, and describes all specified metals, their characteristics and uses. (64)

Small Tubular Parts. The Bead Chain Mfg. Co. Describes Multi-Swage Process for economically custom producing small mechanical parts up to ¼-in. dia and 2-in. length. (65)

Beryllium and Its Alloys. Beryllium Corp., 20 pp, ill. Directory lists a complete line of beryllium products offered by this company, and describes facilities for producing them. (66)

Magnesium Parts. Brooks & Perkins Inc. Characteristics of, and design data on magnesium alloys. Shows examples of magnesium alloys and made-to-order parts produced. (67)

Bronze Bearings. Bunting Brass & Bronze Co., 64 pp, ill, No. 152. Pocket-size booklet contains complete list of industrial standard stock bearings, electric motor bearings and precision bronze bars. (68)

Cemented Carbide Products. Carboloy Dept., General Electric Co., 60 pp, ill, No. GT-250. Specifications and applications of this company's cemented carbide tools and blanks, both standard and made to order. (69)

Investment Castings. Castings Engineers, Inc., 4 pp, ill, No. 17. Discusses advantages of investment castings and characteristics of investment cast parts custom-made by this firm. (70)

Low Melting Alloys. Cerro de Pasco Corp., 40 Wall St., New York 5. Loose leaf binder and informative engineering literature releases for those interested in keeping abreast of new developments in Cerro alloys. Request direct from Cerro on company letterhead.

Phosphor Bronzes. Chase Brass & Copper Co. Folder gives tables of physical and Fabricating properties, uses and forms of this company's phosphor bronzes. (71)

Magnesium and Aluminum Castings. Eclipse-Pioneer Div. Foundries. "Book of Facts" shows company's facilities for custom- making aluminum and magnesium castings. (72)

Metal and Plastics Parts. The Electric Auto-Lite Co., Bay Mfg. Div., 16 pp, ill. Shows wide variety of custom-made ornamental and functional metal and plastics parts. (73)

Investment Castings. Electronicast Inc., 4 pp, ill. Features specifications of the Electronicast process of centrifugal and vacuum investment casting for casting difficult alloys in intricate shapes and to extremely close tolerances. (74)

Aluminum Alloy. Frontier Bronze Corp. Data on Frontier 40-E aluminum alloy, combining high strength, good shock and corrosion resistance, machinability. (75)

Laminated Metals. General Plate Div., Metals, & Controls Corp., 4 pp, ill, No. la. Properties and uses of various laminated metals, including precious metal overlays and laminated silver contacts. (76)

Magnesium Sand Castings. Gerity-Magnesium Corp., 8 pp, ill. Profusely illustrates the facilities of this company for producing various magnesium sand castings from a fraction of a pound up to 500 lb. (77)

Contact Rivets. Gibson Electric Co., 6 pp, ill, No. C-521. Description and specifications of a complete line of Gibson electrical contact rivets. (78)

Metal Powders. The Glidden Co., 3 pp, No. 205. Lists advantages of "Resistox", oxidation resisting metal powders, and includes specification chart. (79)

Welding Nickel Alloy. Illium Corp., 4 pp, No. 105B. Instructions for metallic arc and oxyacetylene gas welding of Illium, nickel-base, corrosion resistant alloy. (80)

Laminated Metals. Improved Seamless Wire Co., Inc., 6 pp, ill. Describes the importance and application of laminated metals to modern industry. (81)

Aluminum Alloy. William F. Jobbins Inc., 12 pp, ill. Includes advantages, composition, physical properties and applications of Almag 35, an aluminum casting alloy of the aluminum-magnesium types. (82)

Cemented Carbides. Kennametal Inc., 16 pp, ill, No. C-53. Describes the characteristics of Kennametal cemented carbides. Includes mechanical and physical properties. (83)

Silicon Bronze. R. Lavin & Sons Inc., 8 pp, ill, Vol. 9, No. 1. "The Lavingot" contains an interesting article on the subject of silicon bronze. (84)

Die Castings. Litemetal DiCast, Inc., 12 pp, ill. How to select best light metal for die casting. Shows facilities for producing light metal pressure die castings. (85)

Die Castings. Madison-Kipp Corp., 32 pp, ill. Describes company's aluminum and zinc die castings. Also shows Kipp Featherweight air grinder and Fresh Oil Lubricators. (86)

Forgings. Mueller Brass Co., 32 pp, ill, No. H-58565. Characteristics and advantages of using brass, bronze and aluminum alloy forgings produced by Mueller. (87)

Precision Casting. Ohio Precision Castings Inc., 12 pp, ill. Numerous examples of industrial applications of this company's brass, bronze, aluminum and beryllium-copper plaster mold castings. (88)

Copper Tubing. Penn Brass & Copper Co., 6 pp, ill. Features of this company's seamless copper tubing. Includes tables of safe internal working pressures of various tubing sizes. (89)

Condenser Tubes. Revere Copper and Brass Inc., 28 pp, ill. Detailed discussion of ways to make condenser tubes last longer, what they are made of, and new developments in materials. (90)

Aluminum Appliance Parts. Reynolds Metals Co., 16 pp, ill, No. FP-104. Profusely illustrates the variety of aluminum appliance parts fabricated by Reynolds. (91)

Centrifugal Castings. Shenango-Penn Mold Co., Centrifugal Castings Div., 6 pp., ill, No. 150. Profusely illustrates a variety of types and sizes of nonferrous centrifugal castings produced by this company. (92)

Aluminum and Magnesium Sand Castings. South Gate Aluminum & Magnesium Co., 12 pp, ill. Features the facilities of this company for producing precision aluminum and magnesium sand castings and precision machined parts. (93)

Flexible Tubing. U. S. Flexible Tubing Co., 16 pp, ill. Description, applications and specifications of this company's flexible metal tubings, bellows for control units, and other metal parts. (94)

Alloy Castings. Wellman Bronze & Aluminum Co., 20 pp, ill, No. 53. Facilities of this company for producing a variety of aluminum sand, semi-permanent and permanent mold form. (95)

Light Metal Forgings. Wyman-Gordon Products Corp., 4 pp, ill. Announces the availability of large-size light alloy forgings, particularly those of magnesium and 75-S aluminum. (96)

Nonmetallic Materials • Parts • Forms

Honeycomb Material. Aircomb Section, Douglas Aircraft Co., Inc. Announces the development of Aircomb, a honeycomb structure of Kraft paper impregnated with a phenolic resin. Pre-cut in any thickness from 1/16 to 5 in., it is said to be 16 times as rigid as an equal weight of steel, durable, fire-resistant, pest-resistant and has excellent insulation and soundproofing properties. (96A)

Molded Plastics, Hard Rubber. American Hard Rubber Co., 80 pp, ill. Handbook of properties, tolerances and weights; design techniques machining and finishing methods for this firm's hard rubbers and plastics. (97)

Molded Reinforced Plastics. American Insulator Corp., 8 pp, ill. Gives numerous uses for molded reinforced plastics; includes physical properties. (98)

Technical Ceramics. American Lava Corp., 12 pp, ill, No. 533. Presents the many advantages of using AlSiMaG technical ceramics produced by this company. (99)

Acrylic Rubbers. American Monomer Corp.,

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4 pp. Properties and recommended uses of Acrylon BA-12 and EA-5 acrylic rubbers. (100)

Polyethylene Adhesive. American Resinous Chemicals Corp., 1 p, No. C-75. Technical data sheet includes specifications of ARCCO 980-21D, a polyethylene adhesive for adhering polyenthylene to paper, aluminum foil and nonporous surfaces. (101)

Custom Extrusions in Thermoplastics. Anchor Plastics Co., 4 pp, ill. Discusses forms and shapes of extruded plastics and gives a general summary as to how thermoplastics can be used by industry. Properties chart included. (102)

Packaging Materials. The Angier Corp., 16 pp, ill. Describes facilities for solving industrial packaging problems and this firm's various types of wrapping materials. (103)

Castings Resins. R. S. Aries & Associates, 8 pp, ill. Includes properties and applications of Aritemp casting resins for electrical work. (104)

Fiber Glass Ducting. Arrowhead Rubber Co., 16 pp, ill, No. 503. Detailed engineering data on, descriptions and applications of this company's Fiberglas flexible and rigid ducting. (105)

Corrosion Proof Sheet and Pipe. Atlas Mineral Products Co., 6 pp, ill, No. 9-1. Complete data on Ampcoflex rigid polyvinyl chloride sheet and pipe for corrosion proof construction. (106)

Polyester Resins. Atlas Powder Co., 10 pp. Describes uses, physical properties and general characteristics of Atlas 100% alkyd-type resins. (107)

Rubber Parts. Automotive Rubber Co., Inc. Series of bulletins show use of rubber for insulation or corrosion prevention in industrial equipment. (108)

Balsa Wood. Balsa Ecuador Lumber Corp., ill. Brochure contains a number of sheets discussing various Kilndried Balsa lumber and Balsa products. (109)

Plastic Sheet. Cast Optics Corp., 13 pp, ill. Description, uses, fabrication and physical properties of CR-39 transparent plastic sheet. (110)

Compounded Elastomers. Chicago Rawhide Mfg. Co., 32 pp, ill. Characteristics, properties and engineering applications of Sirvene compounded elastomers. (111)

Plastics. Ciba Co. Inc. Plastics Div. 625 Greenwich St., New York 14, N. Y. Complete technical data on the physical properties and recommended procedures for the successful use of Araldite Resins for individual fabricating needs. Write direct to Ciba on company letterhead.

Engineered Paper Products. Cincinnati Industries Inc., 16 pp, ill. Complete data on the new double crepe Cindus material called X-Crepe that can be used like cloth, instead of rubber, in place of cork, and for jobs where no other material will do. (112)

Custom Extrusions. Conneaut Rubber & Plastics Co., 4 pp, ill, No. CR-53. Facilities of this company for producing a variety of precision made extrusions. (113)

Spiral Tubing. Continental-Diamond Fibre Co., 8 pp, ill, No. ST-53. Includes specifications of a complete line of spiral tubing, available in many grades. (114)

Molded and Extruded Rubber. Continental Rubber Works, 8 pp, No. 100. Gives dimensions of molded and extruded rubber with cross sectional illustrations. Also condensed SAE and ASTM specification chart. (115)

Plastic. Crane Packing Co., 12 pp, ill, No. T-103. Complete data on Chemlon packings and gaskets fabricated from the new tetrafluorethlyene resin, Teflon. (116)

Polystyrenes. Dow Chemical Co., 8 pp. Complete data on the various Styron formulations with regard to properties, methods of molding, and applications. (117)

Viscose Rayon for Industrial Use. E. I. du Pont de Nemours & Co. (Inc.), Rayon Div., 9 pp, ill, No. A-319. Gives physical properties performance and applications of "Codura", a high tenacity rayon fiber. (118)

Plastics. E. I. du Pont de Nemours & Co. (Inc.), 10 pp, ill, No. 113/3. Descriptions, advantages and uses of Lucite, Polythene Nylon, Butacite, Pyralin, Plastacele and Teflon. (119)

Resin-Coated Glass Fabrics. E. I. du Pont de Nemours & Co. (Inc.), Fabrics Div., 4 pp, No. A-5401. Properties and applications of Teflon tetrafluoroethylene resin-coated glass fabrics, tapes and laminates. (120)

Phenolic Molding Compounds and Resins. Durez Plastics & Chemicals, Inc., 4 pp, ill. Includes types, properties and uses of a variety of Durez phenolic molding compounds, industrial resins and coating resins. (121)

Reinforced Plastics. Dynakon Corp., 2 pp. Data sheet lists complete line of glass polyester laminates produced by this company. (122)

Thermoplastic. Eastman Chemical Products Inc., 16 pp, ill. Attractive booklet discusses Tenite, an Eastman plastic, and gives properties and applications. (123)

Custom Molded Plastics. Erie Resistor Corp., Plastics Div., 4 pp, ill. Illustrated tour through Erie's new Plastics Div. headquarters, showing equipment for manufactured custom molded plastics. (124)

Polyvinyl Chloride Resin. Firestone Plastics Co., Chemical Sales Div., 3 pp, No. 3A. Data sheets discuss Firestone Exon 402A, a polyvinyl chloride resin specifically designed for unplasticized rigid applications. (125)

Flexible Tubing. Flexible Tubing Corp., 8 pp, ill, No. 5-4. Applications and performance data on Spiratube flexible tubing for ventilation and materials conveying. (126)

Plastic and Wood Composite. Gamble Bros., Inc., 4 pp, ill. Announces a new product, Gam-en-Wood, a combination of wood and the new synthetic Enrup. (127)

Rubber-to-Metal Adhesive. General Tire & Rubber Co., Chemical Div., 8 pp, ill, No. 4016. Complete data on Kalabond rubber-to-metal adhesive for noncorrosive solvent-resistant bonding. (128)

Plastic-Faced Plywood. Georgia-Pacific Plywood & Lumber Co., 4 pp, ill. Applications, properties and description of GPX high grade exterior plywood coated with plastic. (129)

Plastic Adhesive. Goodyear Tire & Rubber Co., Inc., 24 pp, ill, No. S-9416. Properties, applications, specifications and data sheets of Pliobond, a quick-setting plastic adhesive that bonds anything to anything. (130)

Plastic Molding. The Grigoleit Co. Folder describes this company's facilities for producing molded plastics. Includes designing, engineering, tooling, molding, and finishing. (131)

Plastics. Heil Process Equipment Corp., 3 pp, ill, Nos. 752, 753, and 754. Discusses the use of Rigidon plastics exhaust heads, duct fittings and ventilating ducts. Specifications included. (132)

Molding Powders, Etc. M. W. Kellogg Co., 20 pp. Buyer's Guide gives complete addresses of firms producing molded and fabricated materials and products made of Kel-F, a trifluorochloroethylene polymer offered by Kellogg. (133)

Acid Proof Ceramic Pipe. Maurice A. Knight, 12 pp, ill. Specifications and description of this company's ceramic pipe fittings, said to be almost universally acid proof. (134)

Polystyrenes. Koppers Co., Inc., No. C-2-169. Features a table giving all the properties of a complete line of straight and modified Koppers polystyrenes. (135)

Fiber Glass Reinforcements. Libbey-Owens Ford Glass Co., 12 pp, ill, No. F-1. Describes company facilities and their applications, gives specifications and descriptions of fiber glass yarns and insulation. (136)

Phenolic Casting Resins. Marblette Corp., 78 pp, ill. This comprehensive manual lists the complete line of Marblette phenolic casting resins, and includes their applications, selection, machining, finishing and fabrication. (136A)

Hardboards. Masonite Corp., 24 pp, ill, No. 1d/2. Properties and advantages of Preswood and other Masonite hardboards, and their relation to product design. (137)

Self Lubricating Bearings. Metallized Carbon Corp., 4 pp, ill. Includes typical mechanical and electrical applications of self-lubricating bearings made of metallized carbon-graphite. (138)

Plastics Tubing. Elmer E. Mills Plastics, Inc., 8 pp, ill. Describes this company's plastic tubing, piping and fittings, including some fabricating data and detailed corrosion information. (139)

Adhesives, Castings, Sealers. Minnesota Mining & Mfg. Co., Adhesives & Coatings Div., 12 pp, ill, No. 2-AMM. Describes the many applications of adhesives, sealers and coatings as used by the automotive industry. (140)

Carbon Products. Morganite Inc., 8 pp, ill, No. 1f. Specifications of various carbon bearings and bushings. Also properties of six series of Morganite carbon products. (141)

Mica Insulation. Mycalex Corp. of America, 24 pp, ill, No. VI. Engineering data on Mycalex, a glass-bonded mica insulation for all frequencies. (142)

Glass Fiber Laminate. Narmco Mfg. Co., 4 pp. Gives description and fabricating methods of Conolon Rigidglas, a pre-stressed fiber glass laminate that can be formed into shapes associated with plywood or sheet metal fabrication. (143)

Carbon and Graphite Brick. National Carbon Co. Catalog lists principal features of carbon, graphite and some typical metallurgical and chemical applications. (144)

Refractory Materials. Norton Co., Refractories Div., 24 pp. Characteristics, types and uses of a complete line of electrochemically refined basic materials produced by Norton. (145)

Rubber. Ohio Rubber Co., 4 pp, ill, No. F-426. Detailed tabulation of the properties

of natural rubber and rubberlike material. (146)

Molded Rubber Parts. Parker Rubber Products Div., Parker Appliance Co., 4 pp, ill, No. 5201A1. Lists the many advantages of using Parker custom molded rubber parts in a variety of applications. (147)

Extruded and Molded Rubber Parts. Republic Rubber Div., 12 pp, ill. Describes facilities for custom manufacture of molded and extruded rubber products. Describes various products. (148)

Fluorocarbon Plastics. Resistoflex Corp. Fluoroflex-T assures the ideal, low loss insulation for uhf and microwave applications and serviceability through temperatures from —90 to 500 F. (149)

Plastics and Fibrous Materials. Rogers Corp., 8 pp, ill. Describes resources, production, research and development facilities, and products of this company's plants for prime and sub-contracting. (150)

Adhesives. Rohm & Haas Co., 10 pp, No. 20R. Describes in detail Uformite 400, a high-solid, aqueous urea-formaldehyde resin adhesive especially designed for bulk shipment and storage. (151)

Cellular Rubber Parts. Rubatex Div., Great American Industries, Inc., 12 pp, ill, No. RBS. Describes properties, uses and advantages of Rubatex closed cell rubber and facilities for making odd shapes to order. (152)

Teflon. Sparta Heat-Treat Co., Plastics Div., 4 pp, ill. Illustrates various Teflon moldings produced by Sparta, and includes a detailed table of typical properties of molded Teflon TF-1. (153)

Rubber Parts. Stalwart Rubber Co., 16 pp, ill, No. 51SR-1. Describes applications and fabrication of rubber compounds designed to resist temperature, abrasion, chemicals and weathering. (154)

Molded Ceramics. Star Porcelain Co. Gives technical data on characteristics of molded ceramic products for electrical wiring, electrical heating and special purposes. (155)

Ceramic Laboratory Ware. Thermal Syndicate, Ltd. Technical description, specifications and prices of Vitreosil ware, said to be superior to porcelain in some uses. (156)

Liquid Polymer. Thiokol Corp., 4 pp, ill. Includes physical properties and typical applications of Thiokol Liquid Polymer LP-2, a viscous liquid that converts to a tough, solvent, resistant rubber at room temperature. (157)

High Temperature Insulation. H. I. Thompson Co., 34 pp, ill. Detailed technical data on Refrasil, giving case histories on performance characteristics as a high temperature insulator. (158)

Plastics Parts. U. S. Gasket Co., 48 pp, ill. Catalog describes properties and uses of Teflon, this company's various Teflon products, and also gaskets of various materials. (159)

Carbon and Graphite Powder. U. S. Graphite Co., 66 pp, ill. Attractively presents detailed information on Graphitar, a carbon and graphite material for seals, bearings and plates, valves, piston liners, etc. (160)

Plastic Rubber Materials. U. S. Rubber Co., 8 pp, ill, No. M-0133. Description, properties, machinability and uses of Enrup plastics, said to fill the gap between rubbers and plastics. (161)

Nonmetallic Gears. Westinghouse Electric Corp., 15 pp, ill, No. B-4661. Description and applications of Micarta gears. Includes tables of properties, gear data and preferred pitches. (162)

Finishes • Cleaning and Finishing

Plating Solutions. Allied Chemical & Dye Corp., General Chemical Div. Outlines how fluoroborate plating solutions are being used in scores of applications to speed up output, cut operating costs and save scarce metals. (163)

Cleaning and Finishing Media. Almco Div., Queen Stove Works, Inc., 10 pp, ill. Features and applications of Supersheen Abrasive Chips and Compounds for barrel finishing and cleaning. Also data on finishing machines. (164)

Rust Preventative. Alrose Chemical Co., 2 pp. Gives preparation and uses of Jetoil No. 1, water soluble oil for blackening ferrous metals by oxidation. (165)

Wet-Blasting Units. The Cro-Plate Co., 4 pp, ill. Describes new line of wet-blasting units for high production deburring, descaling, stock removal and general finishing. (166)

Metal Parts Washers. Detrex Corp., 16 pp, ill, No. 174. Profusely illustrates a complete line of Detrex metal cleaning machines, metal cleaning chemicals and processing equipment. (167)

Wear Resistant Coating. Electrolyzing Corp., 16 pp. Detailed data on the Electrolyzing Process for increasing the life and efficiency of metal parts subjected to wear, abrasion and corrosion. (168)

Precision Finishing Equipment. Hollywood Bronze Supply Equipment Div., 4 pp, ill. Specifications and prices of a complete line of immersion heaters, tanks, rectifiers, assemblies, etc. for finishing. (169)

High-Pressure Cleaners. J. P. Mfg. Co., 4 pp, ill. Typical applications of the new 2500 Series Whirlpool high pressure cleaners that degrease, wash, strip and clean in one operation. (170)

Protective Coating. Lumin Sales Corp., 6 pp. Advantages of using the Luminizing process for cleaning and protecting stainless steel, lacquered surfaces and chromium. (171)

Protective Coatings. Magic Chemical Co., 22 pp. Applications and methods of use of Magic-Vulc anti-abrasion and anti-corrosion plastic rubber coatings. (172)

Silicone-Base Finish. Midland Industrial Finishes Co. Brochure describes silicone-base finish, said to resist heat of 500 F without discoloration. (173)

Aluminum-Chromium Paint. Monroe Co., Inc., 4 pp, ill, No. C-54-8. Includes detailed application data on Monco-alochrom, an aluminum-chromium paint for exterior and interior surfaces of all kinds. (174)

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Coating for Zinc Surfaces. Neilson Chemical Co., No. 48-49. Describes Galvaprep, coating providing good adhesion of paint on galvanized iron, other zinc-coated surfaces. (175)

Zinc Dust Paints. New Jersey Zinc Co., 36 pp, ill. Characteristics and uses of zinc dust paints, most adherent paints for galvanized iron and steel zinc. (176)

Aluminum Cleaner. Northwest Chemical Co., 10 pp, ill. Attractively presents information on the Alkalume Process for preparing aluminum for spot welding. (177)

Rust Remover. Octagon Process Inc. Complete data on the use of Rustclean, available in six types, for removing rust and tarnish. (178)

Drum Cleaning. The Pangborn Corp., 6 pp, ill, No. 220. Brochure explains Rotoblast technique in cleaning drums and covers. Also includes safeguards, specifications and diagrams in operation. (179)

Preparation for Galvanizing. Riverside Foundry & Galvanizing Co., 4 pp, ill. Recommendations for proper preparation of materials prior to hot-dip galvanizing. (180)

Zirconium Glazes for Ceramics. The Titanium Alloy Mfg. Co., 30 pp. Description, uses and properties of TAM zirconium glaze opacifiers. (181)

Heat Treating • Heating

Salt Bath Furnace. Ajax Electric Co., Inc., 4 pp, ill, No. 123-B. Lists 17 ways of increasing heat treating efficiency with the new Ajax submerged electrode salt bath furnace. (182)

Induction Furnaces. Ajax Electrothermic Corp., 8 pp, ill, No. 27A. Advantages and applications of, and equipment for induction heating and melting. Includes selector chart for induction heating and melting. (183)

Burners. American Gas Furnace Co., 48 pp, ill. Various bulletins compiled into one booklet covering the complete line of burners produced by AGF. Specifications included. (184)

Refractories. The Carborundum Co., 20 pp, ill, No. 5120. Describes Super Refractories, the temperatures they withstand, their other properties making them useful as furnace lining. (185)

Furnace Heating Elements. Carborundum Co., Globar Div. Complete data on Globar silicon carbide heating elements, said to be efficient, safe and easy to replace. (186)

Heat Treating Furnaces. The Electric Furnace Co., 6 pp, ill, No. 461. Installations of numerous gas fired, oil fired and electric furnaces describing features and applications. (187)

Rotary Hearth Furnaces. Gas Machinery Co., 4 pp, ill, No. A-102. Complete specifications of the Gasmaco rotary hearth furnaces for forging, annealing heat treating or drawing operations. (188)

Electric Muffle Furnaces. Harper Electric Furnace Corp., No. 346. Features and specifications of this company's line of electric muffle furnaces for such uses as heating

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and annealing. (189)

Salt Bath. Park Chemical Co., No. H-1. Specific application recommendations on the Neutra-Gas Process, an efficient and economical method of maintaining absolute neutrality in chloride-base salt baths. (190)

Annealing and Cleaning Brass Strip. W. S. Rockwell Co., 4 pp, ill. Describes continuous strip annealing process, an operation involving the preparation of brass strip for the annealing furnace. (191)

High Temperature Equipment. Rolock Inc. Catalog gives data on fabricated heat and corrosion resistant alloys for heat treating uses. (192)

Temperature-Sensitive Liquid. Tempil Corp., 1 p. A supplementary sheet of instructions for using Tempilaq, a temperature sensitive liquid for accurately determining attained temperatures. (193)

Ammonia Dissociators. Sargeant & Wilbur Inc., 4 pp, ill, No. A.D. 10. Features, specifications and applications of a variety of this company's ammonia dissociators. (194)

Sub-Zero Chilling. Sub-Zero Products Co., 12 pp, ill. Complete data on sub-zero chilling for alloy steel heat treatment, metal stabilization, gas dehydration, and parts and material testing. (195)

Quenching Oils. Sun Oil Co., 8 pp, ill, No. A-2658. Complete data on Sun quenching oils, which can handle 95% of all quenching jobs in industrial heat treating. (196)

Liquid Carburizing Sales. Swift Industrial Chemical Co., 4 pp, ill. Complete data on Swift polytherm blended liquid carburizing salts for imparting a hard, wear resistant surface to steel. (197)

High Temperature Metal Conveyor Belts. Wickwire Spencer Steel Div., 24 pp, ill. Construction features and applications of various types of metal and wire conveyor belts for high temperature use. (198)

Electric Radiant Panels. Edwin L. Wiegand & Co., 6 pp, ill, No. CS605. Folder includes a variety of applications of Chromalox electric radiant panels—compact, "packaged" for infra-red generators. (199)

Welding • Joining

Electrodes. Air Reduction Sales Co., 50 pp, ill, No. ADC-650. An up-to-date pocket guide to over 30 different Airco electrodes. Includes specifications. (200)

Joining and Sealing Aluminum. All-State Welding Alloys Co., Inc., 6 pp, ill. Gives information on how to use and apply All-State alloys and fluxes for soldering, brazing and welding aluminum and aluminum alloys. (201)

Silver Brazing. American Platinum Works, 48 pp, ill. Reference manual on silver brazing discusses low temperature brazing, brazing alloys, design considerations and other topics. (202)

Stainless Fastenings. Anti-Corrosive Metal Products Co., Inc., 80 pp. Catalog indexes and prices over 7000 varieties of stainless steel screws, bolts and other fasteners. (203)

Screws with Integral Washer. Continental Screw Co., 6 pp, ill. Metal and plastic applications of a screw with the lock washer an integral part of screw head. (204)

Welding Positioners. Cullen-Friestadt Co., ill. Catalog shows line of hand or power operated welding positioners with capacities up to 30,000 lb. (205)

Solders and Fluxes. Division Lead Co., 2 pp, No. PF132. Descriptions of a variety of Divco transistor solders and fluxes produced by this company. (206)

Explosive Rivets. E. I. du Pont de Nemours & Co. (Inc.), Explosive Dept., 39 pp, ill, No. A-2785. Gives sizes, installation and variety of uses of du Ponts' explosive rivets. (207)

Cast Iron Welding Alloy. Eutectic Welding Alloys Corp., 4 pp, ill. Announces the availability of EutecTrode 27, a new noncritical electrode for joining all types of cast iron or cast iron to steel. (208)

Rivet-Type Fasteners. B. F. Goodrich Co., Rivnut Div. Carboard "demonstrator" illustrates working principle of Rivnuts, their construction and applications. (209)

Silver Brazing Alloys. Handy & Harman, 24 pp, ill, No. 20. Information on Easy-Flo and Sil-Fos low temperature silver brazing alloys, and valuable data on brazing methods. (210)

Fasteners. H. M. Harper Co., 2 pp, ill. Pocket-size, accordian-type folder gives specifications on a complete line of nonferrous and stainless steel fastenings. (211)

Solders. Kester Solder Co., 28 pp, ill. Complete analysis of properties and applications of a variety of Flux Core soft solder alloys and soldering fluxes. (212)

Induction Heating for Brazing. Lepel High Frequency Laboratories Inc., 8 pp, ill. Details on induction heating units for accelerated brazing of parts. (213)

Hard Surfacing Electrodes. Lincoln Electric Co., 20 pp, ill. No. 466. The Lincoln "Weldirectory" for hard surfacing includes discussion on arc weld surfacing. (214)

Silver Brazing Preforms. Lucas-Milhaupt Engineering Co., 10 pp, ill. Features an interesting article on the advantages of using silver alloy preforms. Includes detailed specifications. (215)

Electrodes. McKay Co., 4 pp, No. 8. Technical Bulletin No. 8 describes operation and usability of Frogalloy M and C electrodes, and contains chart detailing hardness vs impact of these electrodes. (216)

Rivet Selector. Milford Rivet & Machine Co., A handy slide-chart calculator for selecting the right fastener for each job quickly and easily. (216A)

Preparing Aluminum for Spot Welding. Oakite Products Inc., 18 pp, ill. Presents five important steps to take when preparing aluminum for spot welding. (217)

To obtain literature appearing on these pages, please refer to easy-to-use reply card on page 249

Self-Clinching Fasteners. Penn Engineering and Mfg. Corp., 16 pp, ill. Gives features and dimensional data on this firm's self-clinching and self-locating fasteners. (218)

Nut Clip Fastener. Prestole Corp., 2 pp, ill, No. 751-A. Engineering and application data of a new heavy duty nut clip fastener that rapidly assembles heavier gage sheet metal. (219)

Screws. Russell, Burdsall & Ward Bolt & Nut Co., 8 pp, ill. Presents principles of fastening, advantages and specifications of a complete line of Spin-Lock screws available in hex, pan, truss or flat heads. (220)

Self-Locking Set Screws. Set Screw & Mfg. Co., 20 pp, ill. Illustrates and describes various types of standard and self-locking set screws, with data on dimensions, prices, points and materials. (221)

Self-Locking Nuts. Shakeproof Inc., 6 pp, ill, No. 1. Illustrates seven applications of Keps pre-assembled nuts and lockwashers to otherwise difficult bolted assemblies. (222)

Welding Procedure. Stoody Co. Folder describes welding procedure for repairing metal parts such as top carrier rolls for tractor treads. (223)

Self-Locking Nuts. Standard Pressed Steel Co., Flexloc Locknut Div., 27 pp, ill, No. 619-B. Technical data on a complete line of Flexloc self-locking nuts in both thin and regular design. (224)

Stainless Steel Fasteners. Star Stainless Screw Co. Lists Star's stainless and special machine products available. (225)

Special Fasteners. Tinnerman Products Inc., No. 500. Catalog gives specifications for all of this firm's aircraft fasteners produced under Mil-N-3337 specifications. Describes development and applications. (226)

Special Fasteners. The Townsend Co., 4 pp, ill, No. TL-63. Descriptions and advantages of Nylok Locknuts and Tufflock Nuts, including specifications and available finishes. (227)

Welding Positioners. Worthington Corp., Industrial Div., 36 pp, ill, No. 210 C. Description, features and applications of 100- to 40,000-lb capacity welding positioners. (228)

Forming • Casting • Molding Machining

Coated Abrasive Tools. Behr-Manning Div. of Norton Co., 6 pp, ill. Folder includes problems encountered and explains how they were solved with mechanical polishing coated abrasive tools. (229)

Spiral Milling Attachment. Cincinnati Milling Machine Co., 4 pp, ill, No. M-1715. Features and specifications of milling attachment designed for use in tool and die shops, jobs shops and production shops. (230)

Moly-Sulfide Lubricant. Climax Molybdenum Co., 40 pp. Detailed tables of applications of moly-sulfide lubricant in the manufacturing plant, the job shop and in the field, indicating form used, and results of application. (231)

Coiling Machine. Driver-Harris Co., No. C-52. Information on new coiling machine said to eliminate coil irregularity due to

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work-hardened areas produced during coil formation. (232)

Electron Arc Drill. Elox Corp. of Michigan, 3 pp, ill. Discusses operation, cost of operation, and gives advantages and specifications. (233)

Tungsten Carbide Compacting Tools. National Carbide Die Co., 4 pp, ill. Discusses various tungsten carbide compacting tools as they are applied to powdered metallurgy. (234)

Contour Shear. Wales-Strippit Corp., 4 pp, ill, No. TS. Discusses the Wales True-Edge contour shear for circle and shape cutting, heading and forming. Includes specifications. (235)

Aluminum Extrusion Presses. Watson-Stillman Co., ill, No. 340-A. Describes this company's light metals extrusion presses of 500- to 5000-ton capacities, their features and advantages. (236)

Magnetic Perforating Dies. S. B. Whistler & Sons Inc., ill. Complete descriptions and applications of this company's magnetic perforating dies. (237)

Tube Mills. The Yoder Co., 65 pp, ill. Pros and cons of operating a tube mill, plus detailed information on the process. Also technical data on standard and other equipment. (238)

Inspection • Testing • Control

Test Chambers. American Research Co., 4 pp, ill. Describes the basic environmental test chambers produced by this company for testing under a variety of conditions. (239)

Laboratory Microscopes. Bausch & Lomb Optical Co., 24 pp, ill, No. D-185. Description and specifications of various microscopes for such uses as metallurgical microanalysis. (240)

Diamond Polishing Compound. Buehler Ltd., 4 pp, ill. Price list of Diamet Hyprez, a diamond polishing compound for metallographic specimens. (241)

Testing Machines. W. C. Dillon & Co., Inc., 4 pp, ill, No. LR-2. Complete data on the Dillon Multi-Low-Range universal testing machine. Separate price list sheet included. (242)

Wrattan Filters for Technical Use. Eastman Kodak Co., 343 State St., Rochester 4, N. Y., 78 pp, price 75¢. "Kodak Wratten Filters for Scientific and Technical Use" lists over 100 filters having applications in black-and-white and color photography, and discusses forms and types of filters, their standard uses and care. Write direct to Eastman.

Dewpoint Measuring Equipment. General Electric Co., 8 pp, ill, No. GEC-558A. Complete data on G-E dewpoint recorders and indicators for measuring moisture in gases. (243)

Metallurgical Laboratory Equipment. Harshaw Chemical Co., Harshaw Scientific Div., 12 pp, ill, No. D2637. Catalog describes and gives specifications of this company's available metallurgical laboratory equipment. (245)

Repeated Stress Testing Machines. Krouse Testing Machine Co., 8 pp, ill, No. 46-C. Detailed description of repeated stress testing machines and accessories. Includes specifications. (246)

Compression Tester. National Forge and Ordnance Co., 2 pp, ill, No. 492. Description, features and uses of sensitive, sturdy, low-capacity-compression-crust testing machine. (247)

Spectrographs. National Spectrographic Laboratories, Inc., 4 pp, ill, No. 300. Description, operating principle and control features of spectrograph units for both quantitative and qualitative analysis. (248)

X-Ray Diffration. North American Philips Co., Inc., Research & Control Instruments Div., 8 pp. Booklet contains 20 questions and answers on x-ray analysis. (249)

Testing Machines. Tinius Olsen Testing Machine Co., 24 pp, No. 47. Detailed information on two complete lines of Olsen Super "L" universal testing machines. (250)

Surface Pyrometer. Pyrometer Instrument Co., Inc., 6 pp, ill, No. 168. Complete data on the Pyro surface pyrometer for quick and accurate surface and sub-surface temperature readings. (251)

Radiography. The Radium Chemical Co., Inc., 48 pp, ill. Details of radium radiography, explaining the nature of the equipment and method, recommended techniques and aids to interpreting results. (252)

Tensile Testing Machines. Scott Testers Inc., 6 pp, ill, No. 50. Shows wide assortment of testing machines for testing tensile strength of materials such as rubber, paper, wire and thread. (253)

Thermocouples. Thermo Electric Co., Inc., No. G. Shows large variety of wire-type thermocouple assemblies available in many sizes. (254)

Impact Tester. U. S. Testing Co., Inc., 2 pp, ill. Includes history, description and use of the SPI low temperature impact tester. (255)

General

Heat Exchangers. Corning Glass Works, 8 pp, ill, No. PE-8. Includes charts simplifying the calculation of heat transfer requirements and data on newly designed cascade-type heat exchanger. (256)

High Vacuum Applications. Consolidated Vacuum Corp., 16 pp, ill, No. CEC-1801B. Applications, methods, features, operation and performance of the model 24-101A leak detector in accurately detecting and locating leaks in vacuum or pressure equipment. (257)

Materials Controls. Remington Rand Inc., No. KD367. Booklet describes Kardex system for keeping visible materials and parts inventories coordinated with production. (258)

Air Handling Equipment. The Spencer Turbine Co., No. 107-C. Data book on this company's equipment for the handling and use of compressed air. (259)

Metal Processing. Arthur Tickle Engineering Works Inc., 16 pp, ill. Profusely illustrates the facilities of this company for forging and plate fabricating, metal spraying, and Alumibonding and aluminum casting. (260)

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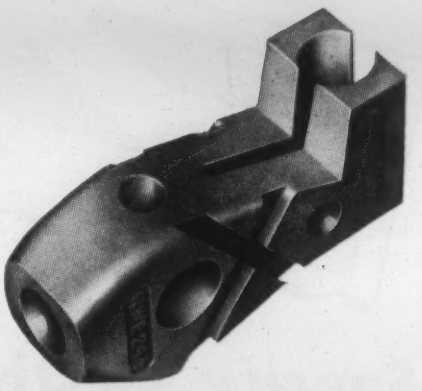

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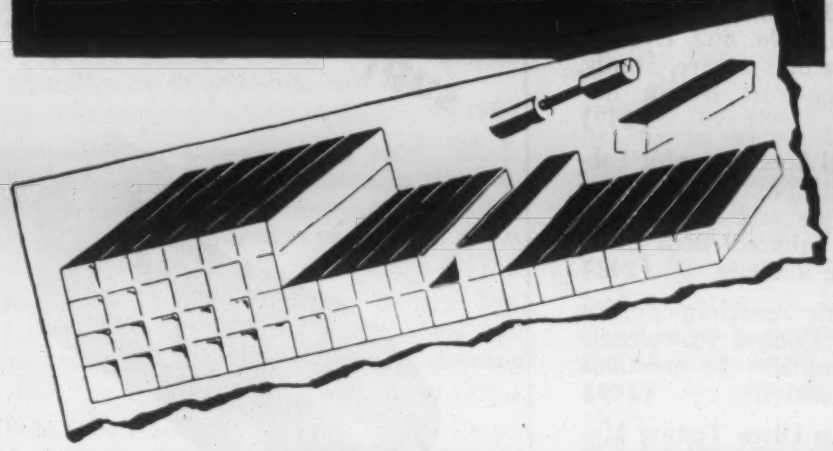

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T.S.	38.3	33.0	33.1	32.7	33.8	36.0	33.8	32.5	33.5	34.5	34.0	37.2	37.8	39.0	36.8	36.5	36.7	40.0
El.	12.5	10.0	6.0	4.0	7.5	7.5	8.0	7.0	7.0	7.5	7.0	8.0	8.5	8.5	7.5	8.0	7.5	10.0

	30	29	28	27	26	25	24	23	22	21	20	19
Y.S.	22.0	23.0	22.5	21.5	22.5	23.5	22.5	23.5	23.5	23.8	22.8	23.8
T.S.	36.3	35.3	35.3	35.0	35.0	37.3	34.5	32.0	32.5	32.5	35.0	38.3
El.	10.0	6.0	9.0	7.5	7.5	6.0	5.0	5.0	5.0	5.0	7.5	7.5

	31	32	33	34	35	36
Y.S.	23.0	22.8	22.5	24.0	23.5	23.0
T.S.	36.3	33.3	32.5	32.5	36.3	39.0
El.	8.0	5.0	5.0	5.0	7.0	8.5

	42	41	40	39	38	37
Y.S.	23.3	23.7	23.0	23.2	23.0	22.5
T.S.	33.2	37.1	36.4	37.3	38.0	40.8
El.	3.0	8.0	6.5	6.5	11.0	11.0

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	T.S.	36600
	El.	7.5

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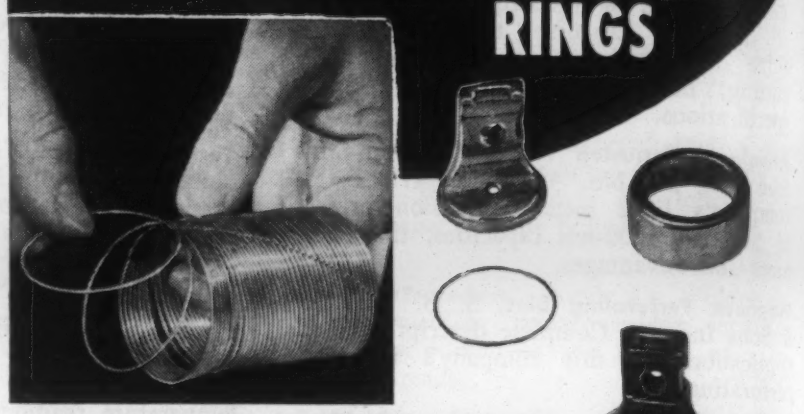

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The Editor's Page

Industrial Speed Up

One of the best dramatizations of how the machine age increases production was recently revealed in a discussion on yarns—real and synthetic. A new machine produces nylon fibers at a rate of 6000 fpm. This compares with 1500 fpm for rayon on existing equipment. The comparison is made much stronger by remembering that most sheep still produce wool at the same old rate—about 3½ in. per year.

Socking the Editor

The pun is purely intentional. A few months ago, this page carried an item about a new nylon yarn for hosiery which permits a whole range of foot and leg sizes to be covered with possible 2 or 3 sizes of hose. By some strange process the item reached the attention of the company making the yarn and they took immediate action. They gave me four socks—the knitted kind—two for myself and two for my wife. They work fine. Now I feel like the television performer who keeps on repeating the word Cadillac, hoping that the proper people will hear it and take appropriate action. Cadillac, Cadillac. . . .

To Coin A Phrase

It's about time somebody did it and now Hydraulic Press Manufacturing Co. breaks the word barrier. It has been rather difficult to find some expression or phrase which would cover all the production methods involving the use of presses. Now the whole gamut is being covered by the term "pressure processing" to cover stamping, drawing, press forging and pressure molding processes. Seems reasonable and useable to us.

Did You Know

Metals and Alloys, from which *Materials & Methods* evolved, was the first industrial sponsor of Battelle Memorial Institute. In the records we are listed as S-1. That was the start of a pleasant relationship which has existed up to the minute and shows every sign of continuing.

See My Incision

Modern technology seems to be reaching the point where nothing is safe from prying eyes. First the candid camera caught us in unguarded moments; next television made unsafe the attendance at a ball game during working hours. Now comes the crowning glory. As of now it is no longer possible to fake an operation as a means of getting an extra vacation. And it's all the fault of some imaginative surgeon who got hold of a bottle of sprayable plastics. Here's what he's done. The good doctor no longer uses bandages to cover up the healing incision after an operation. He now sprays the area with transparent plastics, making it easy to keep tabs on healing progress. This situation could lead to some embarrassing developments such as one of which we have been informed. It seems the almost grown daughter of a certain family had an appendectomy. Her doctor used the new materials and methods. Girl's father proud to have contributed to progress. Net result—all family friends were invited to see the grand opening.

Something to Chew On

This dispatch comes from one of our Chicago spies. Recently a representative of one of the big chewing gum manufacturers dropped into our office out there to pick up tear sheets of an article we published on fluorocarbon plastics. Curious our man asked if there were plans afoot to provide better mileage in chewing gum by adding plastics. That brought an emphatic "No" and also the following bit of information. People with false teeth (or should we call them dentures) are a poor market for chewing gum. Unfortunately, gum tends to stick to acrylic plastics. Thus, in the interest of science and more sales, the gum people are investigating the use of fluorocarbons in making teeth, to take advantage of the well established non-sticking properties of that group of plastics.

T. C. Du Mond
Editor